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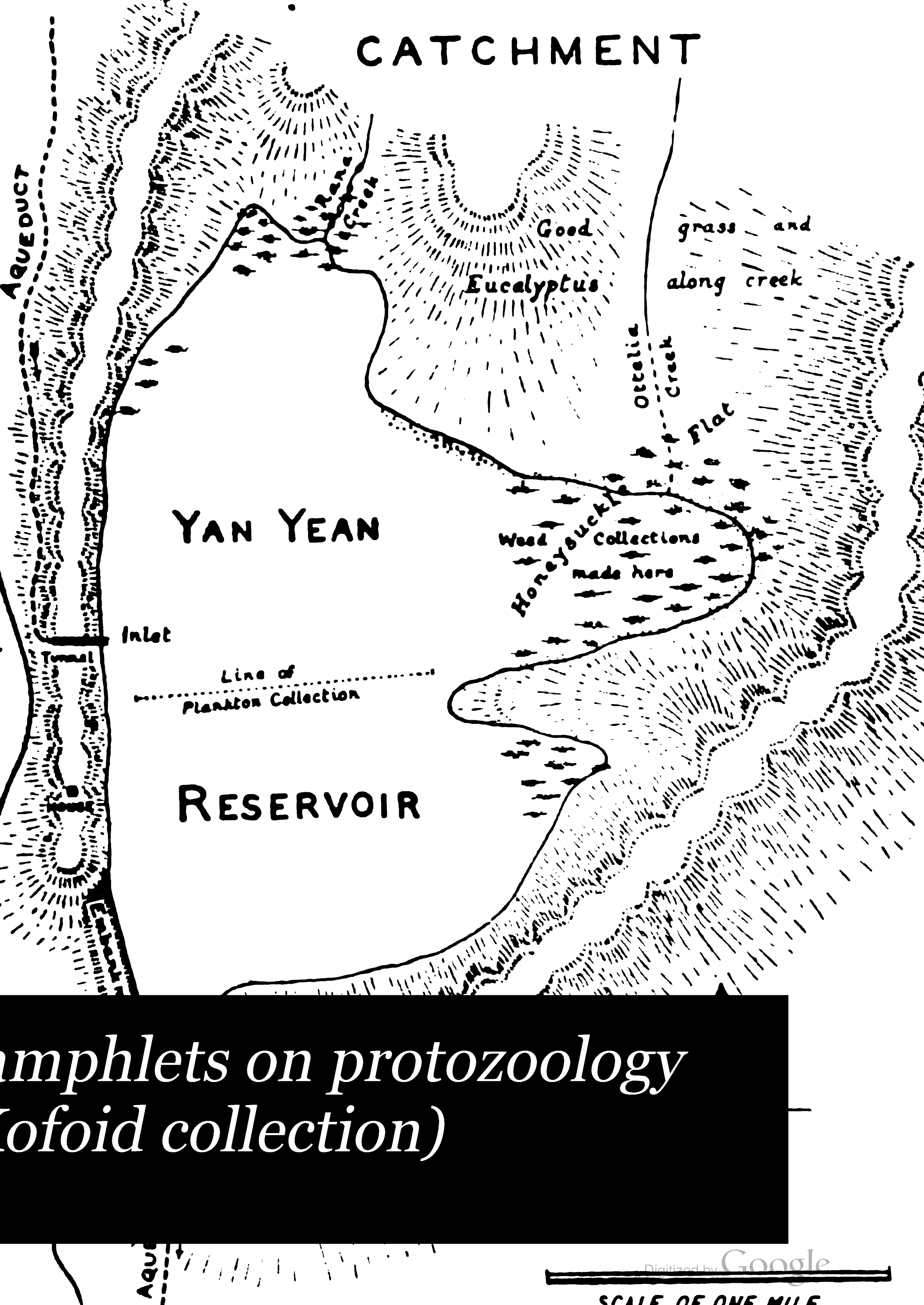

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1

STUDIER
OVER
SØKALK, BØNNEMALM OG SØGYTJE
I DANSKE INDSØER.

AF

C. WESENBERG-LUND.

MED 3 TAVLER OG ENGELSK RESUMÉ.

SÆRTRYK AF MEDDELELSER FRA
DANSK GEOLOGISK FORENING No. 7.

KJØBENHAVN.
TRYKT HOS NIELSEN & LYDICHE.
1901.

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1901.

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Studier over Søkalk, Bønnemalm og Søgytje i danske Indsøer.[1]

Af

C. WESENBERG-LUND.

(Med 3 Tavler og engelsk Resumé.)

Indledning.

Da jeg i Aaret 1897 kunde gøre mig Haab om i en nær Fremtid mere indgaaende at kunne beskæftige mig med Undersøgelse af vore Indsøer, satte jeg mig som Hovedformaal at faa tilvejebragt Oplysninger, dels om vore større Søers Plankton og dels om Aflejringerne paa Søbunden. Plankton kunde den Gang saa vel som nu glæde sig ved det største Antal Bearbejdere, Søbundens Aflejringer lokkede mig som et terra incognita langt stærkere. Allerede samme Aar skrabede jeg hist og her i Furesøen, studerede Søgytjen lidt og fandt den i det følgende beskrevne Bønnemalm. I 1898 foretoges endvidere enkelte Skrabninger i jydske Søer, men da jeg var stærkt optaget af Undersøgelser over Rotiferer og over Plankton og tilmed i disse Aar væsentlig kun havde de tre Sommermaaneder til min Disposition, maatte Bundundersøgelsen hvile til bedre Tider. I Sommeren 1899 foretoges sammen med cand. mag. A. C. JOHANSEN og stud. mag. A. DITLEVSEN en noget mere indgaaende Undersøgelse af Furesøens Bund; jeg fik derved Lejlighed til at lære de vidtstrakte Aflejringer af Molluskskaller i Søen at kende, og da jeg navnlig samme Aar lidt nøjere havde studeret saa vel de rige Kalkbelægninger paa Furesøens *Potamogeton*-Arter som Kalkinkrustationerne paa Strandbreddens Sten, syntes det mig indlysende, at disse kalkproducerende Faktorer ved deres Virksomhed mægtigt maatte bidrage til Søbundens Kalkholdighed. Den Tanke var da nærliggende, at man ved Studiet af disse Faktorer og deres Kalkaflejringer maatte kunne komme det noget taagede Begreb »Sømergel« lidt nærmere paa Livet; samtidig opstod den Tanke hos mig, om ikke Undersøgelsen endvidere vilde bringe Bundarter for Dagen, hvis Kalkprocent var saa høj, at Udtrykket »Mergel« for disses Vedkommende ingenlunde lod sig anvende.

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[1] Foredrag holdte i Dansk geologisk Forening 12. Decbr. 1900 og 17. Januar 1901.

Da jeg ved Studiet af v. Posts og G. Anderssons udmærkede Arbejder havde faaet noget mere Forstaaelse af Gytjer, navnlig Søgytjen, og jeg under mine Planktonundersøgelser i 1898 og 1899 havde stødt paa det i Ferskvand tidligere ukendte døde Plankton, blev det mig samtidig klart, at Søernes Gytje kun vilde kunne forstaas ud fra et nøjere Kendskab til Søernes Plankton, to Begreber, som man tidligere kun i ringe Grad havde sat i Forbindelse med hinanden. Da jeg endvidere i 1899 havde fundet talrige Diatomeer i Bunden af Tjustrupsø og efter Tilsendelsen af N. Hartz' og E. Østrups Arbejde over danske Diatomeeaflejringer og deres Diatomeer var bleven bekendt med fossile Ferskvandsdiatomeelag, tænkte jeg mig Muligheden af, at disse Diatomeeaflejringer endnu foregik den Dag i Dag, og at vore Søbunde muligvis kunde huse Diatomeejorden, endog i dens reneste Form. Sandsynligheden herfor forekom mig saa meget desstørre, som Planktonundersøgelserne samtidig viste, at Diatomeerne i flere af vore Søer havde enormt høje Maksima, og saaledes blev da ogsaa som ventet, Diatomeejorden funden i den Sø (Haldsø), som antageligt af alle viser de højeste Diatomeemaksima.

Samtidig med, at jeg i Efteraaret 1899 begyndte regelmæssigt at iagttage Kalkinkrustationerne ved forskellige sjællandske Søer, lagde jeg Planen for de her publicerede Undersøgelser. Mellem vore forskellige større Søer udvalgte jeg følgende: Furesø, Esromsø, Tjustrupsø, Sorøsø, Tuelsø, Skanderborgsø, Mossø, Julsø, Brassø, Borresø[1]), Hingesø, Haldsø, Viborgsøerne og Madumsø, og besluttede at undersøge Bunden i disse Søer; jeg udelukkede alle saakaldte Kystsøer (Arresø, Filsø o. a.), som paavisligt i en nær Fortid havde staaet i Forbindelse med Havet; ved enkelte Skrabninger i Arresø og Filsø i Sommeren 1899 havde jeg nemlig faaet det Indtryk, at disse hellere burde studeres for sig selv. At jeg blandt de øvrige danske Søer netop valgte ovennævnte, var begrundet i, at jeg allerede Aaret i Forvejen havde paabegyndt regelmæssige Planktonundersøgelser i alle disse (med Undtagelse af Hingesø), hvorfra nu ogsaa Materiale er indsamlet og paa det nærmeste færdigbearbejdet; thi uden Kendskab til Søernes Plankton maatte Undersøgelsen af Søgytjen formentlig altid blive yderst fragmentarisk.

Furesøen valgtes som den Sø, der særlig burde undersøges, og i Foraar og Efteraar 1900 blev dennes Aflejringer af Søgytje, Sømergel og Bønnemalm nærmere studerede samtidig med, at betydelige Indsamlinger af kalkproducerende Organismer foretoges. Allerede fra tidligere Rejser forelaa en Del Bundprøver fra de ovennævnte Søer, hvis Dybdeforhold gennem Lodninger og Samtaler med Fiskere i 1898 ikke var mig ganske ukendte. Da det af flere Grunde var mig af Vigtighed at faa Faunaen i vore dybere Søbunde nærmere undersøgt, foreslog jeg stud. mag. DITLEVSEN, som jeg vidste netop arbejdede med en af de Dyregrupper, der talrigst befolker disse, at foretage Undersøgelsesrejser til de ovennævnte Søer sammen med mig; jeg havde meget ønsket tillige at faa en Deltager, der specielt skulde give sig af med Molluskerne, men dette lod sig desværre ikke realisere.

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[1]) ved Silkeborg.

I Vinteren 1899 og i Aaret 1900 blev da til forskellige Tider de sjællandske Søer og i Juli 1900 de jydske Søer nærmere undersøgte.

Programmet for Undersøgelsen af hver Sø var væsentlig følgende: Optagning og Konservering af Bundprøver fra Søens dybeste Steder og fra Skraaningerne ind imod Land; Sigtning af Bundprøverne i Sigteapparat, Notering og Konservering af Indhold; Temperaturmaaling af Bundprøve og Overfladevand; indgaaende Studium af Molluskskallernes Aflejringsforhold i Søbunden; Iagttagelse af Kalkbelægninger paa Vegetation og paa Strandsten; Indsamling og Konservering af Plankton fra alle undersøgte Søer; tilnærmelsesvis Angivelse af de yderste Grænser for de forskellige Vegetationsbælter.

Undersøgelserne paabegyndtes med, at man roede ud fra Søens ene Ende og, følgende Midtlinien, saa vidt mulig videre ned til den modsatte Ende af Søen; paa denne Ekskursion passerede man i Almindelighed Søens største Dyb og optog undervejs med Skraben Bundprøver, der sigtedes, og hvoraf en enkelt fra det dybeste Parti konserveredes; samtidig indsamledes Plankton, og Temperaturen maaltes. Derefter stak man fra Midterlinien paa forskellige Steder vinkelrette Linier ind paa Land; ogsaa paa disse Strækninger undersøgtes Søbunden paa samme Maade; overalt, hvor man med Skraben kom ind i det senere omtalte Skalbælte, blev dette nærmere undersøgt; saa vidt Tiden tillod det, blev Vegetationen iagttaget, navnlig Kalkbelægningerne, og ved Ekskursioner langs Strandbredden blev Stenenes Kalkinkrustationer studerede.

I August var Planen for Undersøgelsen nogenlunde gennemført, ihvorvel der i Søer med stærkt indskaarne Kyster var Bugter tilbage, hvori Skraben ikke havde været; det midterste Parti af Mossø hindredes jeg ved stærk Storm i at undersøge; endelig naaede jeg i 1900 ikke Madumsø, men havde fra to tidligere Besøg noget Kendskab til Søbunden.

De Apparater, der overalt medførtes, var Skraber, Skrabeline, Lod, Lodline, Sigteapparat, Planktonnet, Thermometer, Glas med Formol og Sprit samt Mikroskop.

Det ligger i Sagens Natur, at der ved Undersøgelser af den her publicerede Art maa rejse sig talrige Spørgsmaal, som det er umuligt for den enkelte alene at besvare; heller ikke formaar man, selv paa de Undersøgelsen mere nærliggende Omraader, at arbejde saa dybt ned, som man kunde ønske, fordi man til Slutning støder paa Problemer af ren fysisk, kemisk, bakteriologisk eller hydrografisk Natur, hvorom Literaturen mig bekendt ikke giver tilstrækkelige Oplysninger, og som det maa tilfalde disse Videnskabsgrenes specielle Dyrkere nærmere at løse.

Det har derfor ikke kunnet undgaas, at det, Forfatteren her har ydet, væsentlig kun fremkommer som et mere detailleret Program for en saadan Undersøgelse, hvori de enkelte Problemer vel er bleven stillet skarpere ud fra hverandre end tidligere og en Del af disse noget klarere belyst, men hvor de forskellige Specialundersøgelsers Resultater endnu ikke har ladet sig kombinere til et samlet Hele; dette maa nødvendigvis blive en Opgave, der hører Fremtiden til.

Der foreligger i Literaturen ingen Meddelelser om Aflejringerne paa de dybere danske Søbunde. Naar man imidlertid erindrer, at Søerne stadig gror til, at Vige afsnøres og omdannes snart til Kær-, snart til Lyngmoser, vil man forstaa, at de her publicerede Iagttagelser er i nær Slægt med og søge at supplere Jap. Steenstrups bekendte Undersøgelser af Skovmoserne Vidnedsdam og Lillemose 1841; de af ham omtalte Kalk- og Kisellag svarer for Mosernes Vedkommende for en stor Del til de Søbundsaflejringer, som vi skal beskæftige os med i det følgende.

Mellem danske Undersøgelser af beslægtet Natur bør endvidere P. E. Müllers: Studier over Skovjord 1878 og 1884 nævnes, samt P. Fejlbergs forskellige Arbejder (Om Enge og tørlagte Arealer 1882; Landmandsbogen 1. Bd. 1895 p. 342 o. a.). De førstnævnte ligger disse Undersøgelser noget fjærnere; de sidstnævnte har vel særlig praktiske For-maal for Øje, men indeholder iøvrigt talrige værdifulde Oplysninger af Betydning for nærmere Undersøgelser over vore større, men lave Søers Dyndaflejringer. Til Slutning bør endnu fremhæves: ARTHUR FEDDERSEN. Bidrag til de danske Indsøers Geografi. Geografisk Tidsskrift. 12. Bd. 1893—94, p. 79.

Jeg bringer min Tak til stud. mag. E. LARSEN, der har bestemt nogle Alger for mig, og til Dr. KØLPIN RAVN, der har gennemset de botaniske Afsnit; ligeledes retter jeg en Tak til de mange, hvem jeg skylder Henvisninger til Literatur, som rimeligvis ellers vilde være undgaaet min Opmærksomhed, særlig til cand. mag. A. C. JOHANSEN, Statsgeolog JESSEN, Museumsinspektør HINTZE, Lektor TUXEN, cand. mag. BØRGESEN, Docent Dr. GUNNAR ANDERSSON, Dr. GRÖNWALL, Professor OPPERMANN og Frk. A. SEIDELIN.

Ligeledes bringer jeg min Tak til Kandidat P. CHRISTENSEN, Assistent ved Landbohøjskolens agrikultur-kemiske Laboratorium, for de nedenfor angivne Analyser af Bundprøvernes Kalkprocent, samt til Lektor C. O. JENSEN, der efter min Anmodning godhedsfuldt har taget de paa Tavle 3 gengivne Mikrofotografier.

Paa Grund af Literaturens yderst forskelligartede Beskaffenhed har jeg anset det for upraktisk at give en samlet Literaturoversigt; jeg har derfor foretrukket, efter de indledende Afsnit, i Begyndelsen af hvert Kapitel eller større Afsnit at samle den dertil benyttede Literatur. Tallene ved Forfatternavnene i Teksten refererer altid kun til den nærmest foregaaende Literaturfortegnelse; et + foran Forfatternavnet betegner, at Arbejdet ikke har været mig tilgængeligt.

Kap. 1. Søbundens kalkproducerende Organismer og Kalkaflejringer.

Det er en ret bekendt Sag, at der i flere af vore jydske Søer findes temmelig vidtstrakte Lag af Kalkaflejringer, populært kaldet »Sømergel«, som hyppigt opgraves af Søerne, køres paa Markerne og anvendes til Jordforbedring; ganske tilsvarende Lag er fundne i Sverrig og finder ogsaa her praktisk Anvendelse, ligesom de kendes fra nordtyske Søer, Schweizersøer (Zürichersøen) o. a.

Skønt »Sømerglen« saaledes er almindelig forekommende, synes man dog kun i ringe Grad at have studeret Betingelsen for dens Tilblivelse og Maaden, hvorpaa den aflejres. Saavel fra botanisk som fra zoologisk Side foreligger der vel Undersøgelser over Kalkproduktionen hos Planter og Dyr, men disse tager alle deres Udgangspunkt fra Organismen og standser der, hvor Spørgsmaalet om Aflejringsmaaderne for den producerede Kalk rejser sig. Omvendt har de geologiske Undersøgelser væsentlig indskrænket sig til at konstatere »Sømerglens« Eksistens og gaar, saa vidt mig bekendt, ikke videre, end til i al Almindelighed at betegne samme som fremkommen, enten ved mekanisk Pulverisering af Organismernes Kalkhylstre eller ved Udfældning af den i Vandet opløste Kalk; men at slaa Bro imellem de zoologisk-botaniske Undersøgelser paa den ene Side og de geologiske paa den anden er hidtil ikke bleven forsøgt.

Det maa a priori forudsættes, at der hersker den nøjeste Sammenhæng mellem den kemiske Beskaffenhed af de Jordarter, hvorigennem alle Søens forskellige Tilløb skærer deres Lejer, og imellem disses Aflejringer ude paa Søbunden. Ved Flodernes eroderende Indflydelse vaskes Jordbunden ud; Floderne transporterer det udvaskede Materiale med sig i deres Løb og aflejrer det i Søerne, hvor det før eller senere synker til Bunds. Saaledes fremfører Forel[1]) (pag. 133) Eksempler paa den nøje Overensstemmelse, der findes, mellem den kemiske Beskaffenhed af det af Floderne aflejrede Materiale, og de Bjærgarters Beskaffenhed, som disse har beskyllet; han viser endvidere, at saafremt en Sø optager forskellige Tilløb, som skærer deres Lejer i ganske forskelligartede Bjærgmasser, vil Søbunden opvise en meget variabel kemisk Beskaffenhed; de af de forskellige Tilløb afsatte Stoffer vil kunne paavises i størst Mængde nærmest Flodmundingerne og jævnt aftagende udefter.

I et Land med en saa kalkholdig Undergrund som Danmark var det rimeligt at antage, at der paa Søernes Bund maatte forefindes betydelige Kalkaflejringer; Undersøgelserne har vist, at dette i Virkeligheden ogsaa er Tilfældet.

Man vil i Almindelighed kunne sige, at der i de fleste større Søer foregaar en Afkalkning af det Vand, Tilløbene fører ud i disse. Denne Afkalkning foregaar væsentlig paa tre Maader:

1) ved mekanisk Bundfældning af de i Vandet svævende Kalkpartikler;
2) ved kemisk Udfældning af den i Søernes Vand opløste Kalk;
3) ved Organismernes Virksomhed, idet disse under deres Livsprocesser binder Kalken og aflejrer den i Form af Kalkbelægninger eller Kalkskeletter.

Paa Grund af Afkalkningen opstaar Søbundens Kalkaflejringer; disse kan iøvrigt ogsaa være fremkomne paa anden Vis og f. Eks. i Egne, hvis Jordbund særlig dannes af Kalk, skyldes den kalkholdige Undergrund, der i saa Tilfælde danner selve Søbunden.

Desværre foreligger der ingensomhelst Meddelelser om, hvor store Kalkmængder de forskellige Tilløb fører ud i vore Søer eller om Vandets Kalkholdighed i disse. Vi maa derfor i dette Arbejde indskrænke os til nærmere at undersøge de Kalkaflejringer, hvis Forekomst skyldes Organismernes Virksomhed, og haabe at fysisk-kemiske Undersøgelser en Gang i Tiden vil gøre Rede for de to andre Aflejringsmaader.

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[1]) Le Léman. 1. 1892.

Da nu Kalkaflejringer, opstaaede ved mekanisk eller kemisk Bundfældning af kulsur Kalk, efter al Sandsynlighed foregaar overalt og samtidig med Kalkaflejringer fremkomne ved Pulverisation af Organismernes Kalkskeletter og Kalkbelægninger, maa man til Stadighed erindre, at de i det følgende omtalte Kalkaflejringer i Virkeligheden er et Fællesprodukt, der skylder alle tre Aflejringsmaader sin Oprindelse; til forskellig Tid og Sted spiller rimeligvis snart den ene, snart den anden af disse Hovedrollen; nærmere at gaa ind paa dette Punkt lader sig paa Grund af manglende Undersøgelser ikke gøre i Øjeblikket.

Ved Spørgsmaalet om Kalkaflejringer fremkomne ved Pulverisation af Kalkskeletter og Kalkbelægninger maa man endvidere altid regne med, at en Del af disse atter opløses af Søernes Vand, og at deres samlede Kalkmængde ingenlunde ubeskaaret overgives Søbunden. Hvor meget, der opløses, afhænger af Kalkskeletternes egen Konstitution og desforuden af ydre Faktorer, ganske særlig af vedkommende Vandmassers Syreholdighed. Idet Vandet saaledes virker opløsende paa Kalkskeletterne, vil man forstaa, at der, samtidig med den store almindelige Afkalkning, tillige kan foregaa Processer af stik modsat Natur, som netop har Forøgelse af Vandets Kalkholdighed til Følge.

I de Tilfælde, hvor Vandmassernes Rigdom paa Humussyrer er meget stor, vil Syremængden foraarsage, at Kalkskeletterne i mange Tilfælde næsten ganske opløses, og at der af de kalkproducerende Organismer kun bliver de kitinholdige Kutikulardannelser tilbage. Dette er navnlig Tilfældet i Tørvemoserne og opgroende Indvige, og de i disse opstaaede Kalkaflejringer er derfor rimeligvis af en anden Oprindelse end Søernes. Jeg formoder, at der mellem to af de store Hovedgrupper for Ferskvandskalken: Søkalk og Mosekalk, for saa vidt de opstaar under Medvirkning af Organismer, vil være den Fundamentalforskel, at Søkalken i alt Fald for en meget væsentlig Del opstaar som Følge af Pulverisering af Kalkhylstrene, Mosekalken derimod først efter at Humussyrerne har opløst disse i Vandet, hvoraf da atter den kulsure Kalk bliver udskilt som Følge af forskellige ydre Faktorers Indgriben[1]).

Da de forskellige Benævnelser: Sømergel, Sneglemergel, snäckgyttja, Søkridt, Seenkreide, craie lacustre, Søkalk, Ferskvandsmergel, Ferskvandskalk, hidtil synes anvendt i Flæng, maa jeg kort gøre rede for den i det følgende anvendte Terminologi.

Ved Ferskvandskalk forstaar jeg alle de i ferske Vande opstaaede Kalkaflejringer, der alle henføres til et af de tre Begreber: Søkalk, Kildekalk og Mosekalk. Af disse skal vi i dette Arbejde kun beskæftige os med Søkalken. Alt efter Dannelsesstedet og Dannelsesmaaden lader denne sig udfra følgende Betragtninger yderligere inddele:

De to Begreber Søkalk og Søgytje er ikke forskelligartede Dannelser; begge bestaar i alt væsentlig af Ler, kulsur Kalk og organiske Stoffer; jeg havde en Tidlang den Opfattelse, at Betegnelsen Søkalk lod sig anvende for de særlig kalkholdige Bundaflejringer, der var forholdsvis fattige paa organiske Stoffer, og at i saa Fald Søgytje kunde betegne de mere kalkfattige, men paa organiske Stoffer rige Bundaflejringer. Undersøgelsen viste mig dog snart, at denne Begrænsning af de to Begreber vilde være ganske unaturlig, samtidig med at det stod mig klart, at de dog begge burde opretholdes. Et af Undersøgelsens Hovedresultater har været Paavisning af, at de kalkproducerende Organismer i vore ferske Vande paa enkelte Undtagelser nær ikke gaar synderlig ud over 11 Meter Kurven; Kalkaflejringer indenfor og udenfor denne Kurve har derfor efter al Sandsynlighed ikke nogen fuldkommen ensartet Genese.

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[1]) Om Mosekalken og dens Genese se nærmere:
E. RAMANN. Forstliche Bodenkunde und Standortslehre. 1893.
— Organogene Ablagerungen der Jetztzeit. Neues Jahrb. f. Mineralogie. Beil. Bd. **10**. 1895—96.

Medens Kalkaflejringerne indenfor 11 Meter Kurven efter al Rimelighed væsentlig opstaar ved Aflejring af de der levende kalkproducerende Organismers pulveriserede Kalkhylstre, dannes Kalkaflejringerne udenfor denne Kurve, enten ved mekanisk Bundfældning af svævende Kalkpartikler eller ved kemisk Udfældning af Søvandets kulsure Kalk; den direkte Aflejring af de paa Stedet levende Organismers pulveriserede Kalkskeletter spiller herude en ganske underordnet Rolle. De udenfor 11 Meter Kurven opstaaede Kalkaflejringer betegnes, saafremt de er forholdsvis rene og ublandede som Søblege, saafremt de derimod er stærkt iblandede med Ler og organiske Stoffer som Kalkgytje. De indenfor 11 Meter Kurven opstaaede urene Kalkaflejringer betegnes som Sømergel. Bundarter derimod, der indeholder mindst c. 80^0 kulsur Kalk, og hvis Kalkrigdom enten skylder Characeer eller Molluskskaller deres Oprindelse, betegnes henholdsvis som Characeekalk eller som Molluskkalk. Ferskvandets Kalkaflejringer lader sig da skematisk opstille saaledes:

I. Søkalk.

Udenfor 11 Meter Kurven	urene Kalkafl., 20—80 $^0/_0$ $CaCO_3$.	*Kalkgytje.*
	rene — , mindst 80 $^0/_0$ $CaCO_3$.	*Søblege.*
Indenfor 11 Meter Kurven	urene Kalkafl., 20—80 $^0/_0$ $CaCO_3$.	*Sømergel.*
	rene — , mindst 80 $^0/_0$ $CaCO_3$	*Characeekalk* *Molluskkalk*

II. Mosekalk.

III. Kildekalk.

De svenske Betegnelser: Bleke og Kalkgyttje, lader sig næppe med Sikkerhed identificere med nogle af de her brugte Betegnelser[1]).

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[1]) Vesterberg. Analys af Kalkgyttja från Martebo myr, Gotland. Geol. Fören. Förh. 17. p. 124. 1895.

Gunnar Andersson. Om nogra växtfossil från Gotland. Geol. Fören. Förh. 17. p. 36. 1895.

Vi skal først omtale Søens kalkproducerende Organismer, senere Kalkaflejringerne.

Kalkproducerende Organismer.

A. Vandplanternes Kalkinkrustationer.

1. HASSACK, C. Ueber das Verhältniss von Pflanzen zu Bicarbonaten und über Kalkinkrustation. Unters. aus dem botan. Inst. zu Tübingen. 2. 1886–88. pag. 465.

2. KERNER, A. Pflanzenleben. 1–2. 1890–91.

3. KOHL, F. Anatomisch-physiologische Untersuchungen der Kalksalze und Kieselsäure in der Pflanze.

4. PFEFFER, W. Pflanzenphysiologie. 1. 1897. (Her og hos Kohl yderligere Literaturfortegnelser.)

5. PRINGSHEIM, N. Ueber die Entstehung der Kalkincrustationen an Süsswasserpflanzen. (Pringsheims Jahrb. f. wiss. Bot. 19. 1888. p. 133.)

6. RASPAIL, F. Nouveau système de chimie organique. 1833.

Det er et fra gammel Tid velkendt Fænomen, at en meget stor Del af de ferske Vandes Plantevækst udskiller kulsur Kalk paa sine Blade og Stængler; mest udpræget og bedst studeret er Forholdet hos Characeerne, men det genfindes iøvrigt hos en stor Mængde andre Vandplanter; selv har jeg fundet Kalkinkrustationer paa *Cladophora, Oedogonium, Fontinalis, Elodea, Ceratophyllum, Myriophyllum, Batrachium,* mange *Potamogeton*-Arter; derimod har jeg aldrig set dem paa *Spirogyra, Zygnema,* paa *Nymphæaceernes* Flydeblade, *Limnanthemum, Hydrocharis, Polygonum, Stratiotes, Potamogeton natans* o. a.

Medens Kalkaflejringerne hos de aller fleste submerse Vandplanter saa vidt vides væsentlig indskrænker sig til Inkrustationer paa Planternes Overflade, aflejres Kalken hos talrige Characeer ikke alene udvendig paa Planten, men ogsaa i krystallinsk Form imellem Barkcellerne og Aksecellen, hos *C. fragilis* endog kun paa sidstnævnte Sted. KOHL (3) pag. 103 og 146.

Man har til forskellig Tid haft en forskellig Opfattelse med Hensyn til Aarsagen til Kalkinkrustationernes Fremkomst. Det ligger udenfor denne Opgaves Plan at gaa nærmere ind paa disse Forhold eller at dømme de divergerende Meninger imellem. Det skal kun fremhæves, at der for Øjeblikket særlig gør sig to Opfattelser gældende. Den ene fremsattes først af RASPAIL (6) p. 321, hævdedes senere af en Række Forskere og blev experimentelt undersøgt af PRINGSHEIM (5); disse Forskere hævder, at Kalkinkrustationerne er en direkte Følge af Planternes Kulsyre-Assimilation, idet disse ikke indskrænker sig til at hente den nødvendige Kulsyre fra den i Vandet opløste Luft, men ogsaa fra den med Calciumkarbonat til surt Salt forbundne Kulsyre; ved Sønderdelingen af Bikarbonatet udfældes da den normale kulsure Kalk paa Assimilationsorganerne. Andre Forfattere, særlig HASSACK (1) og PFEFFER (4) pag. 115, har ikke kunnet slutte sig til denne Opfattelse, navnlig fordi de enkelte Arter, ja endog de enkelte Individer, under samme Kaar forholder sig saa yderst forskelligt, hvad Inkrustationernes Tykkelse angaar. HASSACK har derfor fremsat den Anskuelse, at Udfældningen af kulsur Kalk skyldes alkaliske Stoffer, der paavisligt udskilles af Planterne. Kalkinkrustationernes forskellige Tykkelse skulde da bero paa, at Evnen til alkalisk Sekretion ikke er lige stærk hos alle Planter. Idet HASSACK dog selv fremhæver, at Inkrustationsprocessen kun foregaar samtidig med Assimilationen og ikke, naar denne er stanset (i Mørke), vil man se, at de to Opfattelser dog kun delvis divergerer. KOHL (3) kan hverken (pag. 103) slutte sig til PRINGSHEIMS eller HASSACKS Opfattelse, men mener, at Kalkudskillelsen navnlig er en med Aandedrættet nøje sammenhørende Proces.

Det blev mig hurtigt klart, at denne Vandplanternes inkrusterende Evne spillede en betydelig Rolle ved Dannelsen af Søkalken, og for Characeernes Vedkommende var jeg saa heldig direkte at kunne paavise dette. Da jeg ikke i Literaturen fandt de Oplysninger, jeg ønskede, studerede jeg Forholdene, saa vidt det lod sig gøre, ude i Naturen.

Forfølger man i Løbet af et Aar de forskellige Planters inkrusterende Evne paa forskellige Lokaliteter, vil man først og fremmest lægge Mærke til, at Inkrustationerne overalt er svagest i Foraaret, men tiltager i Styrke, jo længere man kommer hen paa Sommeren; om Efteraaret og henimod Vinteren synes de derimod at forholde sig noget forskelligt. De henraadnende Dynger af *Myriophyllum* og *Ceratophyllum,* som man i November Maaned finder drivende i Søernes Bugter, har som oftest sat deres Inkrustationer til, hvorimod Furesøens store *Potamogeton*-Arter *(P. lucens* og *perfoliatus)* endnu staar rigt inkrusterede, ligesom Inkrustationernes Tykkelse paa *Elodea* synes lige stærke i Eftersommeren, og selv naar Isen lægger sig; paa dette Tidspunkt, er *Elodea*ens friske, grønne Farve fuldkomment skjult af det graagule Overtræk.

Man vil fremdeles paa et hvilketsomhelst Tidspunkt i Sommerhalvaaret lægge Mærke til den store Forskel paa Inkrustationernes Tykkelse hos de forskellige Planter paa en given Lokalitet. Medens *P. lucens* og *perfoliatus* i Furesøen altid findes stærkt inkrusterede, har jeg aldrig i samme Sø set Spor til Inkrustationer paa *Nymphæaceerne, Polygonum* o. a.; dette bliver endnu mere i Øjne faldende i den Sumpvegetation ved Smaasøernes Bredder, hvor tæt til hverandre staaende Planter snart er inkrusterede *(P. perfoliatus, Ceratophyllum, Cladophora)*, snart uden Spor til Inkrustation *(Nymphæa, Hydrocharis* o. a.)

Ligeledes mangler Inkrustationerne overalt, hvor Planterne vokser i stærkt rindende Vand. Dette var saaledes meget tydeligt i Gudenaaen (Juli), hvor f. Ex. *P. crispus* var blottet for al Inkrustation, hvor Aaen var smal og Strømmen strid; derimod kunde den være ret fremtrædende i de større Søer (Gudensø, Julsø, Birksø).

Undersøger man fremdeles Inkrustationernes Mægtighed paa samme Art, men paa dennes forskellige Voksesteder i samme Sø, vil man kunne iagttage betydelig Forskel i Inkrustationernes Tykkelse paa de forskellige Lokaliteter. En *Elodea* og *Fontinalis,* der i Furesøen bringes op fra 8—10

Meters Dybde, er af en lysgrøn Farve og mangler til alle Aarstider ethvert Spor til Inkrustation. I den store Bugt af Furesøen, der betegnes Store Kalven, og hvor man har en enestaaende Lejlighed til at iagttage den pragtfulde Bundvegetation, kan man se, hvorledes Kalkskorperne paa *Elodea* tiltager i Mægtighed, jo nærmere Planten er ved Overfladen; *Elodea*-Puder, der ligger i Bugten ved Fiskebæk kun faa Centimeter under Vandspejlet, er i Eftersommeren gulbrune paa Grund af den stærke Inkrustering. Ganske tilsvarende Iagttagelser kan gøres i Smaasøer; en af de i »Bøndernes Hegn« ved Bagsværd beliggende Smaadamme udmærker sig ved temmelig stejle Sider, beklædte med en rig Vegetation af *Fontinalis*, der danner store, grønne Puder, strækkende sig fra Vandspejlet et Par Meter i Dybet. Disse Puder er stærkest inkrusterede for oven og navnlig lige under Vandspejlet, hvorimod Inkrustationerne aftager jo nærmere ved Bunden, Planten vokser.

Undersøger man fremdeles Kalkbelægningen paa en Plante af betydelig Størrelse, og som paa 3—4 Meter Vand omtrent lodret stiger op til Overfladen (f. Ex. *Potamogeton lucens*), vil man se, at Inkrustationerne er stærkest paa Bladene nær Vandspejlet og langt svagere paa de nærmest Bunden værende Blade. Ældre brunlige Blade, der er ved at gaa i Forraadnelse, mister Inkrustationerne; de aller yngste Skud er i Almindelighed fri for Kalk.

Fremdeles maa det bemærkes, at Inkrustationsgraden er afhængig af Assimilationsorganets Form. Naar Characeerne undtages, gør det Forhold sig øjensynlig gældende, at Inkrustationerne ikke kan finde Sted i saa stærk Grad paa lodrette og cylindriske Organer som paa Oversiden af vandret udbredte Flader. Selv om en Kalkudskillelse finder Sted paa de førstnævnte Plantedele, vil i saa Tilfælde Kalkpartiklerne drysse af *(Potamogeton marinus)*. Hos Planter med brede, udelte Blade *(P. lucens, perfoliatus)* er det altid den opadvendte Side, der er stærkest belagt; i de Tilfælde, hvor Insekter har sammenrullet Bladene, saaledes at Undersiden kommer til at vende opad, bliver derimod denne Side inkrusteret. Mellem de Planter, hvorpaa Kalkinkrustationer hidtil ikke er iagttaget, findes en stor Mængde med Flydeblade *(Limnanthemum, Nymphæa, Nuphar, Polygonum, Hydrocaris, Potamogeton natans).* At i alt Fald enkelte af disse Planter ikke mangler Evnen til Kalkudskillelse, fremgaar deraf, at de bløde, lysegrønne, svagt krusede Vandblade hos Nymphæaceerne hyppig har rigelig Kalkbelægning. Fremtidige Undersøgelser maa godtgøre, om Manglen af Kalkinkrustationer paa Flydebladenes Underside skyldes mekaniske Aarsager.

Ved Studiet af den herhenhørende Literatur vil man formentlig faa det Indtryk, at Kalkinkrustationerne er ret faste sammenhængende Skorper, der, en Gang dannede, vedbliver at sidde henover Bladpladerne. Saaledes skriver Hassack pag. 474: »Ein echter Kalküberzug wie es z. B. an *Chara, Cladophora, Elodea* auftrit wird auch durch das ausgiebigste Abspülen mit Wasser nicht entfernt.« Dette stemmer, naar *Chara* og til Dels *Cladophora* undtages, ikke overens med mine Iagttagelser. Som Undersøgelsesobjekt har jeg fortrinsvis haft *Potamogeton lucens* og *perfoliatus*, men desuden *Batrachium, Elodea, Myriophyllum* og *Fontinalis.*

Naar man med Aaren slaar til en *P. lucens,* vil Kalken drysse af i store Mængder; lægges den op paa Toften i Baaden, vil Planterne, saafremt der kommer en Byge, skylles næsten fuldsændig rene; naar om Efteraaret enkelte Planter rives løs og strander paa Furesøens Bred, mangler disse i Reglen Kalkbelægning, medens Planterne, der vokser faa Hundrede Alen længere ude, staar rigt inkrusterede. Hvor der enten paa Grund af Foldninger i Bladpladen eller paa anden Vis dannes kræmmerhuslignende Aflukker i Bladet eller mellem Blad og Stængel, er Kalken opsamlet som Pulver lige til Kræmmerhusets Rand, idet den fra den øvrige glatte Flade skyller og drysser ned i de omtalte Fordybninger, hvor den kan aflejres og uforstyrret blive liggende. I August Maaned dækkes i Furesøen de store Toppe af *P. lucens* og *perfoliatus* ud over alle Bladene med en

Phryganeelarves fine Spind; Spindet, der navnlig i September bliver meget tæt, opsamler den afdryssede Kalk, der fylder Nettene; Resultatet heraf bliver, at Toppene ikke kan bære den tunge Vægt, men at Stænglerne krummer sig i store Buer, saa at Toppene kommer til at vende nedad. Ved at se ned i Vandspejlet, iagttager man i alle Dybder disse store Stængelbuer krydse hverandre i alle Retninger.

Ved nærmere Studium af Kalkbelægningerne paa Bladene af *Potamogeton*-Arterne ser man jævnligt, at Inkrustationerne optræder i Afsatser; større eller mindre Partier af et Blad kan være dækkede af et tykt Lag gul Kalk, andre Partier kun med et ganske tyndt, næppe synligt Lag, medens atter andre er fuldkommen grønne. Det er højst sandsynligt, at det tykke, gule Lag tidligere har strakt sig ud over hele Bladet; ydre Forhold, rimeligvis Bølger og Vind, har saa bevirket, at Laget er sprængt, og et Stykke af Bladet er kommet til at ligge blot; som Følge af Assimilationen er ny Kalk bleven udfældet, uden dog at have opnaaet samme Tykkelse som det ældre Lag.

Lader man Bladet tørre, kan man med Forsigtighed løsne de tykkere Kalkplader i hel Tilstand og undersøge dem under Mikroskopet; paa den mod Bladet vendende Side ser man da det nøjagtige Aftryk af Bladets Nervation; betragtet med Lupe er denne Side glat og glinsende, under Mikroskopet viser den sig dannet af talrige smaa, uregelmæssige Firkanter, der muligvis er Aftrykkene af Bladets Overhudsceller; paa den af Vandet beskyllede Side er Kalkpladen derimod ru og uregelmæssig; gennem Lupen iagttager man talrige, spidst tilløbende Tappe, der under Mikroskopet viser sig som dannede af utallige, fine Kalkgryn.

Ved at sammenholde disse Iagttagelser faar jeg et noget andet Syn paa Inkrustationsprocessen end tidligere Undersøgere. Kalken opsamles i større tykke Skorper særlig i stille klart Vejr, men skylles af i Storm og af det stærke Bølgeslag. Kalkudskillelsen foregaar formentlig uafbrudt under Assimilationen; Bladpladerne kan ikke i Længden bære den fulde

Vægt af den udskilte Kalk, hvoraf en Del rimeligvis altid drysser af og synker til Bunds i større eller mindre Afstand fra Planten. Inkrustationernes Tykkelse er nøje afhængig af Lyset, den er stærkest paa de Dele af Planten og paa de Individer, der er udsatte for det kraftigste Lys; saalænge vi savner kemiske Analyser af Søernes Vand, maa vi nøjes med at formode, at Skorpernes Tykkelse desuden afhænger af Vandets kemiske Beskaffenhed; at Kalkbelægningerne, saa vidt mig bekendt, mangler paa Planter, der vokser i stærkt humussyrerigt, brunt Vand og altid er stærkest i større, klare Søer, afkræfter i alt Fald ikke denne Formodning.

Naar der imidlertid i vore større Søers Vegetationszone fra talrige Planter daglig finder en uafbrudt Neddrysning af Kalkpartikler Sted, er det klart, at Vegetationen faar en langt større Betydning som kalkdannende Faktor, end man tidligere antog. For nu at erfare, om Kalkprocenten virkelig var større inde under *Potamageton*-Bevoksningerne og *Elodea*-Tæpperne, optog jeg fra Furesøen i September to Bundprøver, den ene midt inde i en tæt Skov af *P. lucens*, hvor Bunden vel viste nogen *Elodea*-Vegetation, men ingen Characeer, den anden ude paa dybt Vand (33 M.). Den første Bundprøve viste 72.41 % $CaCO_3$, den anden kun 35.30 % $CaCO_3$, altsaa knapt Halvdelen. Om end selvfølgelig Mollusklivet, der er langt rigere inde i Vegetationen end ude paa det dybe Vand, har bidraget sit til at sætte den førstnævnte Bundprøves Kalkholdighed op, er det dog højst rimeligt, at Kalkudskillelsen fra Planterne har en betydelig Andel heri.

For at kunne bestemme hvor meget Kalk en Plante paa et givet Tidspunkt kan bære paa sin Overflade, tog jeg med stor Forsigtighed en Del Blade af *P. lucens*, tørrede dem ved svag Flamme mellem to Asbestplader og børstede derpaa al Kalken af. Ved de derpaa foretagne Vejninger af Bladene og Kalken viste det sig, at Bladpladen alt efter dens Størrelse vejede mellem 0.12 og 0.53 Gram, men at Kalken varierede mellem 0.93 og 2.43 Gram, ja i et enkelt

Tilfælde fandt jeg et Blad, der tørret vejede 0.35, og som bar ikke mindre end 4.1 Gram Kalk. KERNER (2) I, pag. 240 angiver, at han paa et Blad, der vejede 0.492 Gram, fandt en Kalkmasse af 1.040 Grams Vægt. Idet en enkelt Plante hyppig bærer c. 30 Blade, vil man se, at samme Plante paa et givet Tidspunkt lavt regnet kan staa med c. 60 Gram Kalk paa sine Blade. Desværre har man næppe noget Middel til direkte at iagttage, hvor lang Tid Planten bruger til at forny denne Kalkmasse.

Da man rimeligvis aldrig ude i Naturen vil støde paa Kalkaflejringer, der alene lader sig henføre til de højere Vandplanters Kalkbelægninger, og da man i alt Fald ved Undersøgelsen af Kalken næppe vil kunne føre Bevis for, at denne virkelig skylder disse sin Oprindelse, vil det være urigtigt at opstille dem som en egen Type.

Ganske anderledes stiller Sagen sig med de Kalkaflejringer, der hidrører fra Characeerne. Saa vidt mig bekendt foregaar der ingen direkte Neddrysning af Kalkpartikler fra disse Planter, men Kalkaflejringerne under Characee-Tæpperne fremkommer, hvad man direkte kan iagttage, ved at de døde Partier brydes i Stykker, synker til Bunds og aflejrer sig om Planten; lidt efter lidt raadner alle organiske Dele bort, men de smaa itubrudte Kalkstykker aflejres med deres Form og Struktur mærkværdig vel bevarede; disse Characeeaflejringer skal vi i det følgende nærmere lære at kende.

B. Skorpedannende, stenklædende Alger.

1. CHODAT, R. Etudes de biologie lacustre. Bulletin de l'herbier Boissier. 6. 1898. pag. 450.

2. FOREL, F. A. Note sur les galets sculptés des lacs. Bulletin de la soc. Vaudoise des Sciences naturelles. 9. 1866.

3. LAMPERT, K. Das Leben der Binnengewässer. 1899. pag. 548–549.

4. RØRDAM, K. Kridtformationen i Sjælland. D. G. U. II. R. Nr. 6. 1897.

5. SCHROETER, C. und KIRCHNER, O. Vegetation des Bodensees. 1897. Bodenseeforschungen: Schriften des Vereins für Geschichte des Bodensees und seiner Umgebung. (Sep.)

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Som bekendt finder man ofte Strandstenene langs vore Søers Kyster inkrusterede med tykke Skorper, som imidlertid ingenlunde overalt har samme Udseende.

Ved Maglesø i Midtsjælland presenterer de sig som tynde, pladeformede, graalige Belægninger; ved Sorøsø som et grynet, hvidt Overtræk; ved Tjustrupsø, i det tidlige Foraar, som et snehvidt, yderst tyndt Lag, der senere hen paa Aaret forsvinder. I Almindelighed (Tuelsø, Tjustrupsø, Furesø) danner Skorperne indtil centimetertykke Belægninger med meget uregelmæssig gennemhullet og furet Overflade; i fugtig Tilstand er disse Skorper blaagraa, undertiden brunlige, i tør Tilstand derimod hvidgraa. Paa mange Bredder mangler Skorperne ganske; saaledes har jeg forgæves søgt dem langs Esromsø, Haldsø og største Delen af Silkeborgsøerne.

Disse Skorper er af meget forskellig Oprindelse; det snehvide, tynde Foraarsovertræk over Stenene i Tjustrupsø skyldes Diatomeer, der senere hen paa Aaret enten slibes af eller overdækkes af andre Planteaflejringer; de øvrige Skorpedannelser bestaar saa godt som altid af kulsur Kalk og maa snart tilskrives visse Grønalger, *Cladophora* (Sorøsø), snart blaagrønne Alger, særlig Slægterne *Schizothrix* og *Rivularia*. Hyppig afgiver Inkrustationerne atter Fæste for andre i kugleformede Kolonier voksende blaagrønne Alger, *Rivularia rufescens*, for Brunalgen, *Pleurocladia lacustris* (Furesø) o. a., og disse kan mod Efteraaret brede sig saa stærkt, at den oprindelige Skorpe dækkes, hvorved det bliver vanskeligt at skælne den primære fra den sekundære Belægning.

Ogsaa her har man med Planter at gøre, hvis kalkinkrusterende Evne ikke kan lades uomtalt, naar Søkalkens Oprindelse drøftes; dog, hvad enten man gennem Literaturen eller ved Studiet ude i Naturen søger at komme til Klarhed over disse Planter og deres Virksomhed, viser det sig, at man her staar over for yderst komplicerede Fænomener. som kun meget grundige og aarevis fortsatte Undersøgelser helt vil kunne udrede.

Det ligger udenfor denne Opgaves Plan at gaa ind paa den rent algologiske Side af Sagen; de Spørgsmaal, der i denne Sammenhæng væsentlig interesserer os, er, hvorfra Algerne faar Kalken, hvormegen Kalk de kan udskille, og hvilken Skæbne denne undergaar, naar Algerne er døde.

Intet af disse Spørgsmaal kan for Øjeblikket besvares tilfredsstillende; men da det har forekommet mig, at Iagttagerne ikke fuldt har udnyttet Studiet ude i Naturen og noget for ensidigt har gjort snart en, snart en anden Opfattelse af de herhenhørende Fænomener gældende, har jeg tilladt mig at fremsætte min Anskuelse, saaledes som den har dannet sig under mine Ekskursioner til Tjustrup- og Tuelsø og ved Iagttagelser anstillede et Aar igennem ved Furesøens Bred; Iagttagelserne gælder i alt væsentligt kun de af Cyanophyceerne dannede Kalkskorper.

Kalkinkrustationerne optræder særlig paa flade, mindre paa stejlt affaldende Kyster; de træffes sjældent paa Sten, der ligger mere end 1 Meter under Vandspejlet, men kan endnu paavises paa saadanne Steder, der ligger c. 2 Meter over Søens almindelige Sommervandstand; stærkest fremtrædende er de i et Bælte af c. 1 Meter paa hver Side af den almindelige Vandstandslinie. Ved Bodensøen, hvor Inkrustationerne, som overhovedet ved de fleste større Schweizersøer, er af større Udstrækning og i det hele spiller en langt betydeligere Rolle end hos os, angiver Kirchner (5) pag. 44, at Bæltet kan have en Bredde af c. 14 Meter. Inkrustationernes Tykkelse varierer fra faa Millimeter til noget over en Centimeter; de findes ikke paa den i Sandet nedstukne Ende af Stenen og er stærkere paa dennes Sider end paa selve Oversiden. I Følge Analyser, Kirchner har ladet foretage af Kalkskorperne, indeholder disse ved Bodensøen c. 52 % $CaCO_3$, c. 22 % organiske Stoffer samt betydelige Mængder Kiselsyre; sidstnævnte hidrører rimeligvis fra de Diatomeebelægninger, som ofte findes uden paa Skorperne. Om Skorpernes vandsugende Evne og Kalkinkrustationernes Betydning for Algerne henvises til Kirchner og Schroeter pag. 44—46.

Algerne kan kun skaffe sig Kalken paa to Maader: enten som de ovenfor omtalte Vandplanter ved at bundfælde den i Vandet opløste Kalk eller ved at tage Kalken fra det Underlag, hvorpaa Algerne vokser. Iagttagelserne ude i Naturen kan angive os, hvilken af disse to Maader Planterne i Almindelighed bruger.

Undersøgelsen af de ovennævnte Søers Strandsten har vist, at Skorpernes Tykkelse er uafhængig af Underlaget, og at Inkrustationerne foregaar lige stærkt, enten Algerne vokser paa Kalksten, Flint eller Granit. Alene heraf fremgaar, at Underlaget ikke spiller nogen afgørende Rolle for Inkrustationen af Planten. Endvidere har det vist sig, at Skorperne ikke er lige tykke ved alle Søens Kyster, men stærkest, hvor Bølgeslaget er stærkest. Dette Forhold finder rimeligvis sin naturlige Forklaring deri, at det netop er her, at Fordampningen og dermed ogsaa Udskillelsen af de opløste Stoffer, i dette Tilfælde $CaCO_3$, foregaar livligst; muligvis er iøvrigt ogsaa Planternes egen Assimilation her stærkere end paa Lækysterne. Kirchner hævder tværtimod mine Iagttagelser, at Inkrustationerne er svagest paa Brændingskysten og mener, at Bølgerne her bryder Skorperne i Stykker og derved hindrer deres Dannelse; muligvis er Forholdet saaledes ved større Søer, hvor Bølgerne har større Magt; ved vore smaa Søer vil man formentlig komme til et andet Resultat. Der er f. Ex. for Furesøens Vedkommende næppe Tvivl om, at Inkrustationerne kun er ubetydelige paa Syd- og Sydvestkysten, men stærkt fremtrædende paa den sydlige Del af Østkysten (Brændingskysten). Det synes derfor højst sandsynligt, at Kalkinkrustationerne væsentlig fremkommer ved, at den i Vandet opløste Kalk af en eller anden Grund slaar sig ned paa Planten; Underlaget spiller her en mere uvæsentlig Rolle.

Paa den anden Side godtgør Studiet af Stenene, at disse undergaar en Hensmuldrings- og Forfaldsproces, under hvilken de ligesom langsomt opædes; under Algeskorperne opviser nemlig Stenenes Overflade lignende dybe Huller og mæandriske Furer som de, der findes i selve Algeskorperne; paa Sten, der længe har ligget over Søens normale Vandstand, og hvor Skorperne forlængst er sprængt fra, er disse stærkt corroderede Overflader særlig iøjnefaldende; overalt ved de paagældende Søers Bredder kan man paavise Overgange mellem større Sten med ubetydelige Huller og Furer og saadanne, hvor Hullerne udgør langt den overvejende Del af Stenens Volumen, idet disse kun adskilles ved tynde Skillevægge af den oprindelige Stenmasse.

Af Stenens petrografiske Beskaffenhed afhænger det, hvor hurtigt Corrosionsprocessen gaar for sig; Kalksten og kalkholdig Flint corroderes øjensynlig stærkest, Graniter derimod i langt ringere Grad.

Man har i Udlandet ofte haft Opmærksomheden henvendt paa de Corrosionsprocesser, som kalkinkrusterede Sten er underkastede; særlig er de bleven undersøgte ved Bodensøen og ved Genfersøen, men begge Steder har man i alt væsentligt indskrænket sig til at iagttage Corrosionsfænomenerne paa Kalkstenene, hvad der formentlig ikke har været til Held for Undersøgelsen. Alle Forfattere fremhæver den Rolle, Vandet i sig selv spiller ved at ætse Stenene og fremkalde disses Furer og Huller; naar Spørgsmaalet derimod bliver om Algeskorpernes Betydning ved Hensmuldringsprocessen, hersker der to ganske divergerende Opfattelser. FOREL (2) pag. 241 hævder for Genfersøens og KIRCHNER (5) pag. 43—51 for Bodensøens Vedkommende, at Algerne langtfra at angribe Stenene, tværtimod danner et beskyttende Dække; derimod mener disse Forfattere, at det er den i Algeskorperne levende Fauna af Phryganeelarver og andre Organismer, der ved at fortære Algerne først frembringer Furerne og Hullerne i Algeskorperne, derpaa i selve Stenmassen og saaledes aabner Vandet Adgang ind til denne. CHODAT (1), der har undersøgt Stenene ved Genfersøen, hævder derimod, at det i første Række er Algerne selv, der angriber Stenene og ved deres Vækst og Indtrængen i Stenmassen frembringer de mæandriske Slyngninger og Huller. Ogsaa efter hans Opfattelse spiller Vandet en yderligere ætsende og udvadskende Rolle, men han hævder, at det er Algerne, der baner Vejen for samme. Schimper (6) pag. 851

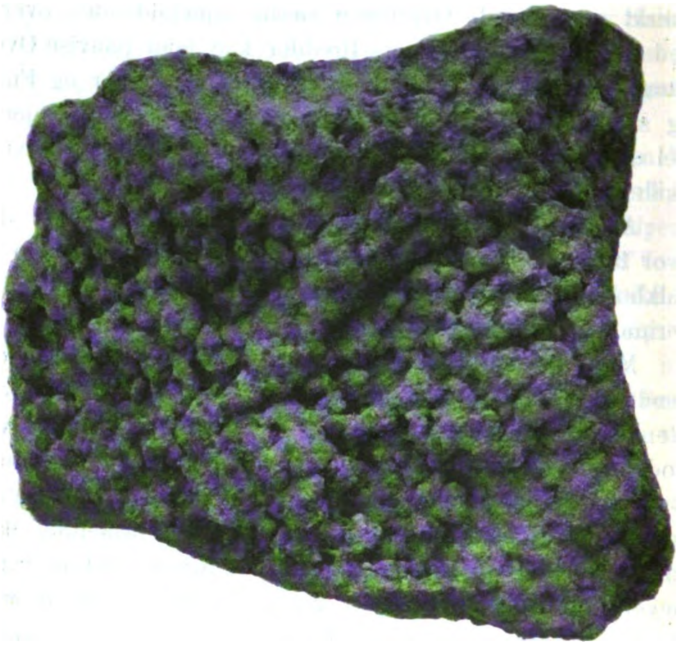

Fig. 1. Flintesten fra Furesøen inkrusteret af blaagrønne Alger. Mærk den uregelmæssige Overflade og de paa denne siddende kugleformede Algekolonier.

søger at mægle mellem disse Anskuelser og synes at mene, at forskellige Faktorer kan virke ved Bodensøen og Genfersøen; hertil maa dog bemærkes, at Forel, der har undersøgt Stenene ved Genfersøen, er kommen til det stik modsatte Resultat af Chodat og netop har dannet sig den samme Opfattelse som den, Kirchner kom til ved Studiet af Stenene ved Bodensøen.

Blot ved en flygtig Betragtning af Algeskorperne faar man uvilkaarlig det Indtryk, at disses stærkt hullede og furede Overflade har været udsat for Angreb udefra og særlig fra Organismers Side; denne Antagelse bestyrkes yderligere, naar man iagttager, at der i Skorpernes Huller og Gange rører sig et rigt Dyreliv, hvis Forhold over for Algemasserne dog er af meget forskellig Natur. En stor Del Organismer, særlig Planarier, Igler, Hjuldyr, Infusionsdyr, ejer ingen Midler til at angribe de haarde Kalkskorper og henter saa godt som alle bevisligt deres Føde paa anden Vis; for dem er Algeskorperne væsentlig kun Flader, henover hvilke de kan glide, eller hvorpaa de kan sætte sig fast. En stor Del andre Organismer, som man særlig har tilskrevet den corroderende Virksomhed, Neuropterlarver *(Rhyacophila)*, Myggelarver *(Chironomus, Tanypus)*, Ephemeridelarver *(Ephemera, Baëtis)* og Perlider er Rovdyr, for hvilke Algeskorperne frembyder Smuthuller, hvor de kan skjule sig, lure paa Bytte og indbyrdes bekrige hverandre; hverken deres Kindbakkers eller deres Bens Bygning lader formode, at de skulde være i Stand til at grave sig Gange i de haarde Kalkskorper. Formodningen om, at de skulde paavirke Stenene ved en Syreudskillelse, er ganske hypothetisk. Selv om de maaske kan udbedre deres Skjulesteder en Del, finder de dem dog i det store og hele færdigdannede og modificerer dem næppe i nogen synderlig Grad. Tilbage bliver da Ostracoderne, Copepoderne, men ganske særlig *Gammarus pulex,* som ofte i utrolige Mængder er til Huse i Gangene og efter al Sandsynlighed virkelig lever et gnavende, rodende Liv i Algeskorperne. Hertil kommer, at man uden paa disse træffer andre Organismer, dels Snegle *(Neritina, Limnæa ovata* og *auricularia)*, som ved at gnave paa Kalkskorperne tilfredsstiller deres Kalkbegær, dels andre Phryganeelarver, *Goëra, Molanna,* som hører til de planteædende Phryganeelarvers Grupper og som, idet de slæber deres tunge stenbelagte Huse med sig, rimeligvis gnaver sig frem henover Algeskorpernes Overflade.

At hele denne uensartede, men hyppig meget individ-rige Fauna nødvendigvis maa influere paa Algeskorpernes Vækst og derved fremkalde en uregelmæssig Overflade, er ret utvivlsomt. Spørgsmaalet bliver her kun, hvor dybt ned i Stenmassen denne Fauna gør sin Indflydelse gældende. FOREL, men særlig KIRCHNER mener, at Dyrene øver deres Indflydelse paa selve Stenmasserne blot ved at grave deres Gange i Algeskorperne, hvorved Vandet faar Adgang ind til Stenoverfladen, som corroderes og hensmuldrer. Men endvidere skal de virke ødelæggende, dels direkte ved at gnave i de corroderede Partier af Stenene og fjærne de pulverformede Partikler, dels paa mere indirekte Vis ved at Vandet, der staar inde i Gangene og Hulerne i Algeskorperne, formedelst Dyrenes Aandedræt mættes med Kulsyre og derved faar en yderligere corroderende Evne.

Selv om der ligger meget til Grund for disse Betragtninger, gør disse Forff. sig dog skyldige i en vis Ensidighed, idet de ikke alene formener, at Algerne aldeles ingen angribende Rolle spiller overfor Stenene, men endog hævder, at Algeskorperne danner et beskyttende Dække henover disse. Ganske bortset fra, at Algerne derved kom til at øve en stik modsat Indflydelse af den, al anden Vegetation (særlig Laver, Mosser og Alger) i Almindelighed plejer at øve paa de Stenarter, hvortil de er fæstede, gives der adskillige let paaviselige Forhold, der absolut taler mod denne Opfattelse.

Slaar man kalkinkrusterede Kalksten i Stykker og undersøger Bruddenes Rande, vil man i de allerfleste Tilfælde tydelig se, at Stenen under Kalkskorpen er angreben; man er ikke i Stand til at angive Grænsen mellem denne og Stenen, idet begge ved et ydre løst hensmuldrende og et indre mere fast Parti gaar jævnt over i hinanden. Paa hvide Kalksten kan man nu tydelig se, at Kalken flere Millm. ned i den faste Stenmasse er blaagrøn; naar Smaastykker fra denne Zone løsnes og lægges i Syre, bliver et Filt af Algetraade tilbage.

Det synes imidlertid, at ikke alene Kalksten, men ogsaa Flintestenene er udsatte for Algernes corroderende Indflydelse.

Selv paa sort og meget ofte paa graa Flint finder man under Algeskorperne en hvid, corroderet Overflade; dog synes det her, som om Stenen ikke er underkastet nogen Hensmuldringsproces, men ligesom bliver ætset ud i uregelmæssige Takker eller Spidser. Som bekendt finder man meget ofte Flinten overtrukket med en hvid Forvitringsskorpe; hvorvidt det simpelthen er denne, man paa Furesøens Flintesten finder under Algeinkrustationerne, eller om denne Skorpe er fremkaldt eller snarere videre udviklet ved Algetæppets Vækst, maa en petrografisk Undersøgelse af Stenoverfladen nærmere afgøre. Saa meget er dog vistnok sikkert, at en Masseundersøgelse af Furesøens Flintesten vil give det Resultat, at Stenene er underkastet en Forvitringsproces af en formentlig meget intensiv Beskaffenhed.

Ved første Øjekast synes det ganske vist højst unaturligt, at endog den sorte Flint skulde lade sig paavirke af de fra et inkrusterende Algetæppe udgaaende kemiske og fysiologiske Processer. Dog maa man erindre, at al Flint, selv sort Flint, indeholder kulsur Kalk, der i Følge Rørdam (4) er tilstede som indstrøede Kalkspathstykker, »som gøre Indtryk af at være tiloversblevne Rester fra en Opløsningsproces« (pag. 73). Prøver af graa Flint indeholdt, i Følge Rørdam (pag. 74) c. 10 % Kalk, en Prøve af sort Flint omgivet af hvid Flint indeholdt c. 4 % Kalk (pag. 61). Det er derfor tænkeligt, baade at Algerne, selv naar de vokser paa Flint, har praktisk Fordel af Underlaget, og at Flinten, idet Kalkspathstykkerne opløses af Algetæppets Syreudskillelse, virkelig er underkastet en fra Algerne udgaaende Corrosionsproces. Chodat har (pag. 453) bevist, at Algerne, hvor disse vokser paa Kalksten, trænger ned i Stenmassen. Der kan derfor næppe være nogen Tvivl om, at Algerne, langt fra at øve nogen beskyttende Indflydelse paa Stenene, snarere er en af Hovedaarsagerne til den første Corrosion. Hertil kommer endvidere, at Stenene er stærkere corroderede paa de Søers Bredder, hvor Algeskorperne findes, end paa de, hvor disse Skorper fattes. Saaledes er Furesøens Sten langt stærkere angrebne end Esromsøs; ja, sammenligner man blot Stenene paa Furesøens Brændingskyst med Lækystens, gør den samme Forskel sig gældende. Faunaen er den samme overalt og er ikke rigere paa de kalkinkrusterede Sten end paa saadanne, hvor Inkrustationerne mangler; her kan den kun ikke gøre sin Indflydelse gældende over for Stenmasserne. Iagttagelserne ude i Naturen godtgør, at Stenene er stærkest angrebne, hvor Algeskorperne er tykkest.

I Følge Chodat spiller Algerne selv den langt overvejende Rolle ved Stenenes Corrosion; i Modsætning til sine Forgængere har han været saa heldig at faa Lejlighed til at iagttage, hvorledes Angrebene fra Begyndelsen gaar for sig. Spredte Kolonier sætter sig fast paa Stenenes Overflade og sænker deres Traade ned i Stenmassen, der corroderes og løsnes, saa at der derved fremkommer et Hul; Kolonierne mødes og vokser sammen, hvorved Stenen angribes over større Omraader, og de mæandriske Furer opstaar; Dyrenes Betydning ved Stenenes Corrosion er i Følge Chodat Planternes langt underlegen.

Ved at sammenfatte alt, hvad vi ved om de kalkinkrusterede Algers Forhold til de Stenoverflader, hvorpaa de vokser, vil Resultatet formentlig blive følgende Opfattelse:

Saavel fra Algernes som fra Dyrenes Side iværksættes der et Fællesangreb paa Stenenes Overflade, som herved corroderes og gennemhulles. Hvorvidt Planterne eller Dyrene under Angrebet er de mest virksomme, kan næppe bestemt afgøres; til visse Tider har rimeligvis førstnævnte, til andre sidstnævnte Overhaand; ogsaa Stenenes petrografiske Beskaffenhed spiller utvivlsomt her en Rolle med. Det første Angreb skyldes sandsynligvis altid Alger, senere hen bidrager Dyrene væsentlig til Destruktionsprocessens videre Forløb, idet de aabner Vandet Adgang gennem Skorperne til Stenoverfladen og derpaa graver de karierede Dele ud.

Det bliver den algologiske Undersøgelses Sag nærmere at udrede, hvorvidt Corrosionsfænomenerne har afgørende Betydning for Algeskorpernes videre Vækst, og særlig om Algerne, i de Tilfælde hvor Underlaget er Kalk, er i Stand til at drage Nytte af denne.

Idet Algerne dels bidrager til Kalkstenenes Hensmuldring, dels til at binde den i Vandet opløste Kalk, har de nogen Betydning ved Søkalkens Dannelse.

Spørgsmaalet om, hvor store Mængder af Kalk Algerne i en given Tid er i Stand til at opsamle, eller med andre Ord, hvilken Tykkelse Skorperne kan opnaa, kan besvares baade eksperimentelt og ved Undersøgelse ude i Naturen. Jeg skal her indskrænke mig til at bemærke, at Skorpernes Tykkelse er yderst forskellig ved de forskellige Søer, og at der efter al Sandsynlighed bestaar et Afhængighedsforhold mellem disses Tykkelse og Vandets Kalkholdighed i den paagældende Sø. Desværre ejer vi endnu ingen kemiske Analyser af vore forskellige Indsøers Vandmasser, men det fremgaar af de i det følgende Kapitel meddelte Procenter af disse Søbundes Kalkholdighed, at de kalkinkrusterede Sten navnlig findes ved Bredderne af de Søer, hvis Søgytjer udmærker sig ved høj Kalkprocent; saaledes optræder de ved Bredderne af Tuelsø, hvor Søgytjens Kalkholdighed er 59.14, ved Tjustrupsø (Kalkholdighed 46.98), ved Furesø (Kalkholdighed 35.30), derimod mangler de ved Esromsø (Kalkholdighed 14.14), Haldsø (Kalkholdighed 3.00), Julsø (Kalkholdighed 0.10), Mossø (Kalkholdighed 1.3). At der bestaar et Afhængighedsforhold mellem Søbundens og Søvandets Kalkholdighed er i alt Fald i høj Grad sandsynligt¹). — Til Besvarelse af Spørgsmaalet om Kalkens videre Skæbne, naar Algerne er døde, skal følgende Meddelelser tjene.

Ved regelmæssig Iagttagelse af Furesøens Stenflora et Aar igennem og ved Rejser til Tjustrup- og Tuelsø i April, Juli, Oktober og December har jeg set, at Floraen ikke er

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¹) Det maa dog bemærkes, at jeg ikke sikkert har kunnet paavise et lignende Afhængighedsforhold mellem Søbundens Kalkholdighed og Kalkbelægningerne paa højere Planter.

den samme Sommer og Vinter. Om Vinteren er Stenene hyppigst dækkede med tykke, sortebrune, tjavsede Diatomeebelægninger; i April, Maj forsvinder disse samtidig med, at Cyanophyceernes Skorper breder sig over Stenene. Skorperne tiltager i Tykkelse til hen paa Efteraaret; i den varmeste Sommertid, naar Vandstanden synker, lægges mange Sten blot; de soltørres, og Skorperne springer, ruller sig opad og faar Udseende som tørret Hundelav (Tjustrupsø, August 1900); dels aflejres de ved Foden af Stenene, dels gribes de senere hen under Efteraarsstormene af Bølger; sent paa Efteraaret er Skorperne sprøde og henfaldende. I den strænge Vinter 1899—1900, da Furesøen var tilfrossen i et Fjerdingaar, pressedes Isen ind paa Sydøstkysten, skurede Stenene rene for Alger, og da den atter gik bort, var der kun ubetydelige Rester af Skorper tilbage; den foregaaende meget milde Vinter, da Søen aldeles ikke var tillagt, og der kun havde dannet sig en svag Isbræmme langs Kysten, var Stenene dækkede med de ovennævnte tykke Diatomeebelægninger. Det synes heraf at fremgaa, at Soltørring og Is er de to store Faktorer, der afskræller Stenenes Kalkbelægninger og bidrager til disses Aflejring andet Steds.

Iagttager man de soltørrede, opadrullede Algeskorpers Underside, ser man, at de er dækkede med hensmuldrede Partier af Stenenes Overflade, og at ogsaa denne under Skorperne er pulveriseret. Som bekendt skørner Sol og Frost Stenenes Overflade; denne Hensmuldringsproces fremmes saaledes yderligere gennem Algers og Dyrs Virksomhed.

Jeg har saavel om Vinteren som om Sommeren søgt Aflejringer, der kunde lade sig henføre til pulveriserede Kalkskorper, for gennem saadanne Aflejringers Mægtighed at lære de kalkinkrusterede Algers Betydning ved Søkalkens Dannelse nærmere at kende; alle mine Bestræbelser har i saa Henseende været ganske forgæves, og jeg havde lidt efter lidt dannet mig det Indtryk, at disse Algers Rolle paa dette Omraade var af ganske underordnet Natur. Det fremgaar imidlertid af Kirchners Arbejde pag. 52, at slige Aflejringer i Virkeligheden kan opstaa; Forholdene ved vore Søer er dog for smaa til, at de her kan gøre sig gældende. Ved en Del af Bodensøens Kyst (»am oberen Ende von Langenargen«) har Kirchner fundet »eine Art von Sand mit organischer Grundlage«. Dette Sand bestod af ulige store, temmelig bløde Korn af hvidgul Farve; disse Korn stemmede i Udseende og Struktur ganske overens med Brudstykker fra Stenenes Inkrustationer. Kornene dannedes af kulsur Kalk og efterlod, naar Kalken blev opløst, smaa fnuggede Klumper af brunlig Farve, som ved nærmere Betragtning viste sig at bestaa af en sammenfiltret Masse: tomme Cyanophyceeskeder, hvori enkelte Algetraade endnu med Sikkerhed lod sig føre tilbage til netop de Alger, der danner Kalkinkrustationerne paa Bodensøens Sten.

Hermed er imidlertid ogsaa leveret Beviset for, at Søkalkaflejringer faktisk kan opstaa ved Pulverisation af de kalkinkrusterede Algers Skorpedannelse.

C. Kalkproducerende dyriske Organismer.

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Den eneste Dyregruppe. der i Ferskvand spiller nogen større Rolle som kalkproducerende Faktor, er Molluskerne. I vore ferske Vande optræder c. 100 Arter. hvoraf en ikke ringe Del enten paa Grund af deres Sjældenhed eller formedelst Skallernes store Tyndhed kun har ringe Betydning for Dannelsen af Kalkaflejringer; et stort Antal findes særlig i Moserne eller i de større Søers halvt tilgroede, moseagtige Vige, men fattes paa de aabne Kyster; de vedkommer os derfor her, hvor Talen kun er om Søkalkens Dannelse, i mindre Grad. Hjemmehørende i vore større Søer er væsentlig kun Slægterne: *Unio, Anodonta, Pisidium, Bithynia, Valvata, Neritina* samt af Slægten *Limnæa* Arterne *auricularia, ampla, ovata,* i noget sjældnere Grad *stagnalis* og en Del mindre *Planorbis*-Arter. som ved Dannelsen af Søkalken næppe spiller nogen større Rolle; de større Arter *P. corneus* og *umbilicatus* findes. for saa vidt de optræder i større Søer, i Almindelighed ikke udenfor de tilgroede rolige Bugter; enkelte sjældnere Former, *Hydrobia, Amphipeplea*, ser vi her ganske bort fra. Ogsaa *Paludina* er ret sjælden, den mangler i adskillige af vore større Søer og holder sig, saa vidt mine egne, ufuldstændige Undersøgelser strækker sig, ligeledes væsentlig til de lave, rolige Vige.

Med Hensyn til Studiet af Ferskvandsmolluskernes Betydning for Søkalkens Dannelse rejser der sig atter her særlig tre Spørgsmaal: Hvorfra hidrører den i Skallerne aflejrede Kalk, under hvilken Form og paa hvad Maade aflejres den, og hvorledes foregaar Opløsnings- og Hensmuldringsprocessen, naar Dyrene er døde og den af dem bundne Kalk atter overgives til Yderverdenen; man kunde maaske mene, at kun det sidste Spørgsmaal kunde have nogen Betydning for Undersøgelsen over Søkalken; det vil dog snart vise sig, at dette ikke kan besvares uden i Forbindelse med de to foregaaende. — Det er nødvendigt at omtale den af Muslingerne og den af Sneglene producerede Kalk hver for sig.

Som bekendt føres der en stadig Vandstrøm gennem Muslingernes Legeme, idet Vandet gaar ind gennem den nedre Kappeaabning og med regelmæssige Mellemrum atter udstødes gennem den øvre saakaldte Gataabning. De i Vandstrømmen værende Stoffer, som har Betydning for Muslingen, holdes tilbage af denne for at omsættes og aflejres i dens Legeme. Blandt disse Stoffer er ogsaa de forskellige Kalksalte, som enten findes opløste i Vandet eller findes i de forskelligartede Smaapartikler, som tjener Dyret til Næring. Med Rette siger Bischoff (1) pag. 585, at Muslingerne er »Pumpeværker af overordentlig Virksomhed og Ydeevne«. For at kunne bestemme, dels hvor store Mængder Kalk en Musling er i Stand til at producere, og dels hvor meget Vand, der i den Anledning strømmer gennem dens Legeme, undersøgte han nærmere Forholdet hos Østersen. Af 10 forskellige store Østers vejede Skallerne fra 2.78 til 7.57 Gange saa meget som selve Dyrene. Til Dannelsen af disse Skaller angiver han, at Muslingerne har forbrugt 345 til 587 Pund eller henholdsvis 5.2 til 8.9 Kubikfod Havvand. Disse Vandmasser beløber sig henholdsvis fra 27760 til 75714 Gange saa meget som Østersernes Vægt. Bischoff gaar ud fra som givet, at det alene er den i Havvandet opløste kulsure Kalk, som bindes af Dyrene, og som afgiver Materiale til Dannelsen af Østersskallerne. Hvad nyere Undersøgelser over Oprindelsen til de kalkproducerende marine Organismers Kalkskeletter angaar henvises særlig til Irwine og Woodheads (7) Arbejder; da lignende Undersøgelser over Ferskvandsorganismer, mig bekendt, ikke foreligger, kan vi ikke her gaa nærmere ind paa disse Forhold. Vi maa derfor indskrænke os til at bemærke, at Tilbøjeligheden til at binde den kulsure Kalk ikke er lige stor hos alle Arter. Selv paa Eksemplarer af *Unio* og *Anodonta*, der lever Side om Side, er Skallerne dog i Almindelighed tykkere hos førstnævnte end hos sidstnævnte. Ligeledes er det vel bekendt, at Kalkaflejringerne ikke foregaar med lige stor Intensitet, men er svagest i Muslingernes første Levetid og stærkt tiltagende senere hen. Hazay (5) pag. 141 mener, at Muslinger, der lever i kalkfattigt, kulsyreholdigt Vand, bliver smaa og tyndskallede, hvorimod de tykskallede Former særlig fremkommer i kalkholdigt Vand.

Sneglene kommer paa noget anden Vis end Muslingerne til den kulsure Kalk. Idet vore Ferskvandssnegle saa godt som alle overvejende er Planteædere, er det navnlig den af Planterne bundne Kalk, der atter aflejres i Snegleskallerne. Man kan i denne Sammenhæng gøre opmærksom paa det store Antal af *Limnæa* (særlig *L. ovata* og *ampla*, mindre *Planorbis*-Arter, særlig *P. albus* o. a.), som træffes under Characeebuskene inde paa lavere Vand, samt det ikke ubetydelige Antal af *Valvata* og *Bithynia*, som er knyttede til de store Characeebevoksninger ude paa dybere Vand, og hvorfra Skraben kun sjældent bringer andre Planter end Characeer op. Paa de kalkinkrusterede Fanerogamer, særlig *Potamogeton lucens*, træffes hyppig et stort Antal Limnæer, særlig *L. ovata*, men ogsaa *L. auricularia*; Bladene er belagte med Snegleekskrementer af samme Farve som Kalkinkrustationerne, ikke grønligsorte som Ekskrementerne hos de Limnæer, der lever paa Mosevegetation. Planterne selv er mærkelig lidt beskadigede af Sneglene og frembyder aldrig det Billede paa Ødelæggelse som Mosevegetationen om Efteraaret, særlig *Stratiotes*-Tæpperne, saa godt som altid afgiver. Utvivlsomt tilfredsstiller Sneglene deres Begær efter kulsur Kalk ved at slikke Kalkskorperne af Bladene. De store Exemplarer af *Limnæa auricularia,* som har til Huse paa de blaagrønne Algers Kalkskorper paa Stenene inde paa lavt Vand, opholder sig rimeligvis her af ganske samme Grund. Hvorvidt Stahl (11) pag. 71 har Ret, naar han hævder, at Planternes stærke Kalkbelægninger tjener til Beskyttelse mod Sneglenes Angreb, maa henstaa uafgjort og synes mig i alt Fald ingenlunde bevist ved de anstillede Forsøg i Laboratoriet.

Hos Heynemann (6) pag. 113 findes iøvrigt samlet en Række interessante Eksempler paa Sneglenes, navnlig Landsneglenes store Forkærlighed for Kalk og deres massevise Optræden paa kalkholdige Lokaliteter. Zschokke (16) pag. 241 gør opmærksom paa, at Bjærgsøer, der ligger i Kalkbjærge, har et rigere Molluskliv end de, der ligger i kalkfattige Egne. Ved at sammendrage alt, hvad vi ved om Maaden, hvorpaa Muslinger og Snegle skaffer sig den til deres Skaller nødvendige Kalk, synes det at fremgaa, at Muslingerne direkte kan udnytte den i Vandet opløste Kalk, Sneglene derimod kun den Kalk, som allerede er bunden af andre Organismer.

Det næste Spørgsmaal omfatter Maaden, hvorpaa den af Molluskerne erhvervede Kalk aflejres. For at kunne fastholde denne og aflejre den i Form af et beskyttende, særlig mod Vandets opløsende Evne uangribeligt Eksoskelet, maa Kalken omgives af organisk Materiale. Mængden af Syrer i Vandet kan stige saa betydeligt, at Molluskerne faar en haard Kamp at bestaa, idet Kalken opløses lige saa hurtigt, som Dyrene har faaet den dannet; hele deres Livskraft koncentrerer sig i saa Tilfælde paa at modarbejde Vandets kalkopløsende Egenskaber (Hazay [5] pag. 47). Maaden, hvorpaa Kalken aflejres, eller med andre Ord, Molluskskallernes Bygning er ingenlunde den samme hos alle Arter; en Generalisering fra en Type til en anden er derfor ikke tilladelig. Særlig maa man holde de to Hovedgrupper af Ferskvandsmollusker, Muslinger og Snegle, ude fra hinanden; da man desværre kun for Ferskvandsmuslingernes Vedkommende har nøjere Kendskab til Skallens Struktur, men mangler saadan for de forskellige Ferskvandssnegle, skal vi i det følgende kun beskæftige os med Skalstrukturen hos Muslingerne.

Skallerne af *Unio* og *Anodonta,* der her behandles under et, idet Forskellen mellem dem ikke er synderlig stor, bestaar af tre Lag: yderst af en Kitinkutikula, hvis nøjere kemiske Sammensætning iøvrigt næppe er opklaret, dernæst af et Prismelag bestaaende af Calcit og sammensat af et forskelligt Antal over hverandre liggende Lag af lodret staaende Kalkprismer indbyrdes adskilte ved en mellemliggende organisk Substans, Conchiolin, og endelig af det saakaldte Perlemoder- eller Lamellag, bestaaende af Aragonit og sammensat af et Antal vandrette Lag af Kalk, ligeledes adskilte fra hverandre ved tynde, paa forskellig Vis indbyrdes forbundne Conchiolin-Lameller. Conchiolinens kemiske Sammensætning er ikke sikkert kendt; man angiver i Almindelighed, at den næppe afviger stærkt fra Kitinens.

Hos *Cyclas* skal i Følge LEYDIG (9) pag. 49 Prismelaget mangle og Conchiolinlamellerne ikke være faste, sammenhængende Plader, men gennemkrydsede af talrige Kanaler. Hos visse Najader, særlig hos Flodperlemuslingen, *Unio margaritifer,* skal Dyrene i Følge WINTER (15) pag. 2 yderligere paa saadanne Steder i Perlemoderlaget, hvor der er særlig Trang til dem, aflejre brune, uregelmæssige Conchiolinblade; tilsvarende iagttages ofte paa danske Arter.

Det synes af sidstnævnte Forfatters Undersøgelser endvidere at fremgaa, at Ferskvandsmuslingernes Skaller ikke indeholder synderlig større Mængder organisk Substans (af ham betegnet som Kitin), end der i Almindelighed angives for Molluskernes Vedkommende; saaledes indeholder 1 Gram Skal af Flodperlemuslingen 60 mg. Conchiolin eller 6 %, forskellige *Anodonta*-Arter noget mindre, c. 3—5 %, *Unio pictorum* 3—4 % og *U. crassus* 2—$3^1/_2$ %. Derimod kan man vistnok som Regel sige, at Kutikulaen i det hele er betydelig tykkere hos Ferskvandsmolluskerne end hos de marine Former.

Af de tre ovennævnte Lag dannes Kutikula og Prismelag af Kapperanden, Perlemoderlaget derimod af hele Kappens Overflade; Skallerne vokser i Omfang ved Nydannelser langs Kapperanden, i Tykkelse ved, at der fra Kappens hele Overflade afsondres Conchiolinlameller, mellem hvilke Kalkaflejringerne foregaar.

Det vilde føre for vidt her at gaa ind paa alle de talrige Spørgsmaal, der opstaar ved et nærmere Studium af Molluskskallerne, hvis Dannelsesmaade som bekendt afgiver et af de mest omstridte zoologiske Objekter. Der er saa meget mindre Opfordring hertil, som Stempel (12) pag. 595 meget udførligt gør Rede for de forskellige Opfattelser, der i Tidens Løb er fremkomne med Hensyn til de Steder, hvor Dannelsen af de organiske og uorganiske Skaldele i Dyrenes Legemer foregaar, Maaden hvorpaa de dannes og Stedet og Formen for deres Aflejring. Vi maa her indskrænke os til følgende.

Molluskskallernes yderst komplicerede Bygning er det synlige Udtryk for den Kamp, der fra Dyrets Side føres for at bevare den en Gang indvundne Kalk; kun paa Grund af, at Kalken gemmes i Sække og aflejres mellem Hinder af organisk Materiale, bliver den i Stand til at danne det Dyret beskyttende Eksoskelet.

Mellem den ovenfor af Planterne og den af Molluskerne producerede Kalk eksisterer (naar Characeernes til Dels undtages) altsaa den Fundamentalforskel, at Kalken hos førstnævnte ikke er omgiven af organisk Materiale og heller ikke har den skeletdannende Betydning som hos Molluskerne. Idet det organiske Materiale dels værner Kalken mod Vandets opløsende Evne og dels giver hele Massen forøget Fasthed, modstaar Dyrenes Kalkskeletter i lang højere Grad end Planternes saavel de ved Vandmassens og Søbundens Syreindhold fremkaldte Opløsningsprocesser som den ved Bølgeslag og anden mekanisk Paavirkning fremkaldte Hensmuldring; fra denne almindelige Regel maa dog som nævnt Characeerne undtages.

Hvorledes foregaar da Molluskskallernes Destruktion.

efter at Dyrene er døde? Vi skal her særlig omtale Destruktionen paa dybere Vand, senere den, der foregaar inde paa lavt Vand.

Tager man enkelte gamle, for længst bundfældede Skaller, f. Eks. af *Valvata piscinalis,* op og lægger dem i Pérényis[1]) Væske, bruser de overordentlig stærkt og er bogstavelig talt forsvundne i Løbet af c. 10 Minutter; ofte finder man i Væsken ikke Spor tilbage af Skallen; tager man derimod en levende *Valvata*, piller Dyret ud og lægger Skallen i Vædsken, foregaar Processen meget langsommere, den strækker sig over flere Timer, og i Syren efterlades de organiske Dele, nøje angivende Snegleskallens Form. Forskellen mellem den subfossile og den recente Skal er altsaa den, at Conchiolinen og Kutikulaen er forsvunden i førstnævnte. Man støder nu i de gamle Skallejer, der i det følgende nærmere skal beskrives, paa Skaller, der viser alle Overgangsstadier mellem saadanne, der endnu indeholder en Del Conchiolin og saadanne, hvor denne helt er tilsat. I sidstnævnte Tilfælde kan Skallerne være bløde og plastiske og flyder i vaad Tilstand ved den svageste Berøring ud til en kridtagtig Masse. Skaller af denne Beskaffenhed er af FUCHS (2) pag. 186 beskreven fra Alt-Ausseer See, han siger herom: »Das Merkwürdigste bestand jedoch darin, dass sämmtliche Schalen vollkommen weich und plastisch waren, so dass man sie in der Hand zu einer teigartigen Kalkmasse zusammendrücken konnte. . . . . Beim Austrocknen wurden die Schalen jedoch wieder vollkommen hart.« Fænomenet er ikke sjældent paa 7—11 Meter Vand, og kan navnlig for Najadernes og Valvaternes Vedkommende ofte paavises i vore større Søer. Fra denne bløde, plastiske Tilstand, hvori gamle Molluskskaller ude paa dybere Vand saaledes befinder sig, og som rimeligvis begynder, saasnart Conchiolinen er forsvunden, er der kun et Skridt til Skallens yderligere Pulverisation, der har Molluskkalkens Dannelse til Følge.

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[1]) Pérényis Væske bestaar af: 3 Dele $^1/_2$ % Chromsyre, 4 Dele 10 % Salpetersyre og 3 Dele absolut Alkohol.

Ved Undersøgelse af en stor Mængde gamle Skaller i de forskellige Forfaldsstadier kan man nærmere forfølge Destruktionsprocessernes Gang.

Først og fremmest lægger man Mærke til, at Kutikulaen som oftest er sprængt fra over større eller mindre Dele af Skallen; undertiden mangler den ganske.

Kutikalaens Frasprængning foregaar ikke lige let og lige hurtigt hos alle Arter; Lokalitet og Dyrets Alder øver ogsaa deres Indflydelse. Medens saaledes Skaller af *Valvata* og *Bithynia*, navnlig af førstnævnte, ude i de dybere Skallejer som oftest mangler Kutikula, er denne hyppig bevaret hos mange Limnæer; hos *L. ovata* antager den ofte efter Dyrets Død, paa Skaller aflejrede paa dybere Vand, en ejendommelig rustrød Farve; ligeledes bevares den længe hos Planorberne. Hos Ferskvandsmuslingerne er den i subfossil Tilstand næsten altid forsvunden paa de nærmest *apex* liggende ældste Partier, hvorimod større Dele langs Skalranden for det meste er dækkede af Kutikulaen. I Vande, der er rige paa Humussyrer, opløses Kalken, og Kutikulaen bliver tilbage som store, brunsorte Kitinflager. Undersøger man Molluskskaller fra gamle, forlængst tørlagte Sneglelag, finder man tilsvarende Forhold. Kutikulaen er her i Reglen bevaret paa Limnæer og Planorber, delvis paa Bithynier; hos Valvater mangler den i Almindelighed; Muslingeskaller har saa godt som altid mistet større eller mindre Partier af den; noget almindeligt kan dog vanskeligt siges.

Ved nøjere Iagttagelse af *Unio* og *Anodonta*-Skallerne ser man (Tavle 1, Fig. 9), at der paa de Steder, hvor Kutikulaen har løsnet sig, ligger et grynet Pulver, der smuldrer ved Berøring, men som hyppig mangler paa de Partier, hvor Kutikulaen helt er forsvunden Dette Pulver er det henfaldende Prismelag, der sandsynligvis forsvinder nogen Tid efter, at Kutikulaen har hævet sig op og givet Vandet Adgang.

Naar man med Lupen undersøger talrige Skaller med frasprængt Kutikula og Prismelag, ser man, at Perlemoderlaget kun angribes stødvis; Vandets opløsende Evne hindres nemlig af Conchiolinen i at gøre sig fuldt gældende; saa snart et Conchiolinlag er sprængt, vaskes Kalken ud, hvorpaa Processen hæmmes af det næste Conchiolinlag, som maa opløses, inden den kan gaa videre for sig. Idet Conchiolinlaget som oftest giver efter paa et enkelt Punkt, hvorigennem Vandet trænger ind, og hvorfra Corrosionen straaleformet breder sig til alle Sider, og idet de over de udvaskede Partier beliggende Lameller forsvinder, corroderes Skallerne i Afsatser; med Lupen kan man undertiden paa Grubernes Afsatser se Conchiolinlamellerne rage frem som brune Blade; jo ældre Skallerne er, og jo mere der er forsvundet af Conchiolinen, des hurtigere gaar selvfølgelig Processen for sig. Lignende Iagttagelser har WINTER (15) pag. 10 anstillet for *Unio margaritifer*.

Erfaringen lærer os, at det for Ferskvandsmolluskernes Vedkommende kun er undtagelsesvis, at en Molluskskal, efter at Dyret er dødt, har bevaret sin Kutikula uskadt. Som oftest er Kutikulaen allerede medens Dyret lever sprængt fra paa visse Partier af Skallen og Corrosionen i den underliggende Kalk i fuld Gang. Det er nu ganske indlysende, at Dannelsen af Molluskkalken i høj Grad fremskyndes, naar Skallerne allerede ved Dyrenes Død er i mer eller mindre defekt Tilstand; derved bliver de nemlig langt lettere og hurtigere tilgængelige saavel for Vandets opløsende Egenskaber som for mekaniske Paavirkninger, der har Skallernes Hensmuldring til Følge. Heraf fremgaar imidlertid atter, at de Skallerne corroderende Faktorer i Virkeligheden spiller en meget stor geologisk Rolle.

Ved Studiet af Literaturen faar man formentlig det Indtryk, at Skalcorrosionen snarest er bleven studeret som et conchyliologisk Kuriosum og uden Forstaaelse af, at disse corroderende Faktorer i Virkeligheden er Naturens vigtigste Redskaber ved Pulveriseringen og Opløsningen af den af Organismerne bundne Kalk. Det forekom mig derfor naturligst i et særligt Afsnit dels at behandle den herhen hørende yderst spredte og vanskelig tilgængelige Literatur, dels at meddele et Par nye Iagttagelser, som Undersøgelsen har bragt frem. Vor Mangel paa Kendskab til de enkelte Sneglearters Skalstruktur bevirker imidlertid, at de følgende Meddelelser kun er af fragmentarisk Natur, der væsentlig kun har Betydning som Basis for mere indgaaende Undersøgelser.

Aarsagerne til Molluskskallernes Corrosion.

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4. Bornet, E. & Flahault, Ch. Sur quelques plantes vivants dans le test calcaire des mollusques. Bulletin de la Soc. botan. de France. 36. 1889. pag. 147.

5. Brot, A. Etudes sur les coquilles de la famille des Najades qui habitent le Bassin du Léman. Association zoologique du Léman. 1866. (Sep.)

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8. Chodat, R. Etudes de biologie lacustre. Bulletin de l'herbier Boissier. 6. 1898. pag. 431.

9. + Clessin, S. Die Corrosion der Bivalven. Correspondenzblatt des zool. miner. Vereins Regensburg. 25. 1871.

10. + — Ueber den Einfluss kalkarmen Bodens auf die Gehäuseschnecken. ibd. 25. 1871. pag. 50—58.

11. — Beiträge zur Mollusken-Fauna Deutschlands. Malacozoolog. Blätter. 25. 1878. pag. 141.

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20. Steenstrup, J. Optegnelser om danske Dyrs Forekomst og Levemaade. Naturh. Tidsskrift. 2. 1838. pag. 538.

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Corrosionen af Ferskvandsmolluskernes Skaller er et fra gammel Tid meget vel kendt Fænomen; om Aarsagen til samme har man derimod haft højst forskellige Anskuelser. Noll (18) angiver, at Corrosionen skyldes særlige kalkædende Organismer: *Micrococcus conchivorus;* Schuttleworth (Bielz [2] pag. 3) opfatter Corrosionen som et Alderdomsfænomen, Brot (5) som en Sygdom hos Molluskerne selv. De to sidste Opfattelser rummer nogen Sandhed, men træffer ikke Hovedet paa Sømmet. De fleste Forfattere ser i Vandets kemiske Sammensætning og i ydre Faktorers Indgriben Hovedaarsagen til Corrosionen. Nogle: Bland (3) pag. 306, Bielz (2) pag. 8, Vest (22), Heynemann (15) pag. 137, lægger Hovedvægten paa Vandets opløsende Evne, og der anføres hyppigt Eksempler paa, at

Skallerne er mest corroderede i kulsyreholdigt Vand, mere i Smaasøer og Moser end i store Søer, mere i kalkholdig Lerbund, mindre i Sand o. s. v. Andre synes især at lægge Vægt paa den mekaniske Side af Sagen og mener, at Sliddet mod Bundens Sten og Grus er Hovedaarsagen til Corrosionen. For Muslingernes Vedkommende mener Bielz, at man kan paavise en særlig mekanisk Corrosion fremkaldt navnlig af Bundarten og en kemisk, fremkaldt af Vandets opløsende Egenskaber. Den kemiske Corrosion gør sig særlig gældende ved »Ausgefressensein der Schalen«, den mekaniske derimod ved »eine Abreibung der Wirbel«.

Clessin hævder (9) pag. 127, (12) pag. 81, at kun den Del af Muslingen, der stikker fast i Bunden, er corroderet, den frit i Vandet fremragende Del viser ingen Tegn til Corrosion. For Vierwaldtstättersøens Vedkommende viser Surbeck (21) pag. 473 imidlertid, at Muslingerne her netop er corroderede paa den Del, der rager frit ud i Vandet, medens den Del, der stikker ned i Dyndet, ikke opviser nogen Corrosion; øjensynlig forholder Muslingerne alt efter Vandets kemiske Beskaffenhed og de forskellige Bundarter sig forskelligt i de forskellige Søer.

Fischer (13) pag. 303, Wiechmann (25) pag. 95, Clessin (12) pag. 79 gør opmærksom paa, at Skalcorrosionen hos Sneglene hyppig skyldes det Faktum, at de, hvor de ydre Omgivelser ikke byder dem tilstrækkelig Næring, stjæler den til Dannelsen af Skallerne nødvendige Kalk fra Kammeraternes Huse, hvorved der opstaar dybe Huller og Furer i disse. Baade Fischer og Wiechmann har iagttaget Fænomenet paa Snegle i Akvarier; førstnævnte mener tillige at kunne paavise, at Molesteringerne foregaar stærkest i Bække med Sandbund. Wiechmann formoder, at det navnlig er i det tidlige Foraar, naar Vinterlivet hører op, at Sneglene særlig stjæler fra hverandre; Clessin hævder, at ogsaa Kutikulaen skulde have Betydning som Fødemiddel. Allerede tidligere, 1838, har iøvrigt Steenstrup (20) pag. 530 vist, hvorledes *Helix nemoralis* paa de sandede Bakker, Mulebjærgene nær

Lille Vildmose, afgnaver hverandres Huse endog i den Grad, at de to nederste Vindinger kan være helt bortædte.

Endelig har et Par Forfattere henledt Opmærksomheden paa den Betydning, visse Alger har for Corrosionsprocessen. Saaledes skriver Fischer (13) pag. 309: »Les Cryptogames aquatiques des genres Chætophora, Batrachospermum etc. déposent sur le têt leurs germes entourés d'un encroûtement calcaire comme les étoiles de certains Chara, et qui doivent les reproduire. Dans le moindre fendillement de l'épiderme, amené par la chaleur, se glissent les germes de ces plantes, qui en se développant le font éclater et produisent des érosions irrégulières souvent considérables.«

Endvidere omtaler Clessin (12) pag. 80, at han har fundet *Limnæa stagnalis,* hvor Skallen var ganske overtrukken med Alger. »Die Algen frassen während ihres Wachsthumes die Gehäuse an und liessen punkt- oder streifenförmige bis zur dritten Schichte eindrungende Grübchen zurück, welche die Gehäuse in ihrer ganzen Ausdehnung bis hart an den Mundsaum bedecken. . . . . Im Herbste zogen sich die Algen an den Gehäusen in kleinen kugelige Wärzchen zusammen.«

De store Algeduske, der ofte findes fasthæftede paa levende Limnæers Skaller, skal efter Lemmermann (16) pag. 36 være af Betydning for Sneglen ved at afgive Skjul og Værn mod Sneglenes Fjender; Brockmeier (7) pag. 258 foretrækker derimod at lade dem være til Skade for Dyrene, idet de hæver disse op fra Søbunden og foranlediger, at de kommer i Drift.

Ud fra et botanisk Synspunkt og uden særlig Hensyntagen til Algernes Betydning for Corrosionsprocessen har først Bornet og Flahault (4), særlig dog paa marine Skaller, og senere navnlig Chodat (8) undersøgt Alger, der lever et parasiterende Liv i Skallernes Kalkmasser; vi skal i det følgende komme tilbage hertil.

Dernæst skal jeg gaa over til mine egne Iagttagelser.

Jeg havde tænkt mig, at man ved Undersøgelse af talrige corroderede Individer ude i Naturen kunde blive i Stand til af Corrosionsbilledet at slutte sig til den corroderende

Faktor; ad denne Vej naar man dog ikke saa langt, som jeg havde formodet; Corrosionsbillederne frembyder nemlig i de allerfleste Tilfælde overordentlig stor Lighed, og meget ofte angribes en Skal af mer end en Faktor.

Ved at undersøge det store Antal Individer ude i Naturen og sammenholde deres Udseende med de Forhold, hvorunder Corrosionen foregik, mener jeg i alt Fald dog at kunne henlede Opmærksomheden paa følgende Fænomener.

Det har vist sig, at Corrosionen er stærkest i Moser og smaa Vandhuller med rig Vegetation, mindre i større Søer, den er mere fremtrædende inde ved disses Bredder end ude paa dybere Vand. Corrosionen er endvidere mest iøjnefaldende om Efteraaret og i det tidlige Foraar; af de meget stærkt corroderede Skaller, som Limnæer og Planorber opviser, naar de, umiddelbart efter at Isen er forsvunden, indfinder sig i Breddernes Opskyl, faar man det Indtryk, at Corrosionen er gaaet for sig hele Vinteren igennem. I Vande rige paa Humussyrer, der ved Frostens Indtræden som bekendt udskiller sig i hvide, fnuggede Masser og synker til Bunds, øver muligvis den stærkere Koncentration af Syremængden i og umiddelbart over Bunden sin corroderende Indflydelse paa Skallerne af de Dyr, der er gaaede i mer eller mindre fast Vintersøvn paa Mosebunden.

Wiechmanns (25) Formodning om, at Sneglene navnlig stjæler Kalken fra hinanden i det tidlige Foraar, tror jeg er rigtig; særlig i den Tid har jeg nemlig set Sneglene beslikke hverandres Huse og klumpe sig sammen i Hobe paa 3—4 Individer. Beskaffenheden af den Bundart, hvori Muslingerne graver deres Gange, har afgørende Indflydelse paa Skallernes Beskaffenhed; Corrosionen er stærkest i blød Mudderbund, mindre stærk i Lerbund, svagest i Sand- og Grusbund. Særlig i Gudenaaen fik jeg Lejlighed til at iagttage dette; de mindst corroderede Skaller fandtes, hvor Strømmen var stærk, og hvor Mudderet ikke kunde faa Ro til at blive aflejret, samt i Mossø og i den store Sandslette, der i Julsø ligger ud for Alling Bakker; de stærkest corroderede Skaller stammer derimod fra Gudensø, hvor Bunden bestod af stinkende Mudder og fra Bredninger, hvor Strømmen var svag og Sandet overlejret med Mudder. Allerede tidligere har Clessin (12) pag. 81 vist, at Corrosionen er stærkere i blød Lerbund, end i Sandbund.

Corrosionen foregaar endvidere altid mest intensivt paa den ældste Del af Skallen, den, der hidrører fra Dyrets første Levetid, da det endnu var ungt og ikke formaaede at beskytte sit Hus tilbørligt; og da det hos Muslingerne netop er den ældste Del af Skallen, der er udsat for det største Slid, idet netop dette Parti først støder paa den Modstand, som Bundarten, hvori Muslingen lever, frembyder, bærer Partiet om Muslingernes *apex* ganske særlig Mærker af Corrosion; kun undtagelsesvis har disse bevaret Kutikula og Prismelag ubeskadigede.

Ved Studiet af Corrosionen af de levende Individers Skaller bliver man snart klar over, at man maa holde to ganske forskelligartede Kræfter: de Kutikula frasprængende og de kalkopløsende ude fra hinanden: de førstnævnte er af mekanisk, de sidstnævnte særlig af kemisk Natur.

Undersøgelsen af talrige Skaller lærer os, at der, saalænge Kutikulaen kun er hel og uskadt, ikke finder nogen Corrosion af Skallen Sted. Kutikulaen, der bestaar af Kitin eller et dette meget nærstaaende Stof, har stor Modstandskraft overfor Syrer; alene disse Kitinhudes ofte massevise Optræden i Tørvelagene er et talende Bevis herfor. Selv om Vandets eller Søbundens Syreholdighed er stor, vil denne derfor næppe øve nogen synderlig Indflydelse paa Kutikulaen. Derimod kan man blot ved Brugen af en Kniv vise, at denne navnlig paa Skallens ældste Partier er forholdsvis sprød og ikke altid hæfter lige godt til det underliggende Prismelag; i saa Henseende forholder de forskellige Arter, ja endog de forskellige Individer, alt efter de uensartede Forhold, hvorunder de har levet, sig ganske forskelligt; for alle Formerne gælder det dog, at en ydre mekanisk Faktor: et skarpt Stykke Grus, en Snegls Tungerasp, en Alges Tryk kan ridse eller skrabe et Hul og derved lægge den underliggende Kalk blot; saaledes faar Vandet Adgang til Kalken, og først da tager den egentlige Corrosion af Skallen sin Begyndelse. Intensiteten af denne Proces afhænger først og fremmest af Vandets Syreholdighed; ikke sjældent støder man paa Individer, hvis Kutikula vel er noget beskadiget, men hvis Skaller kun opviser en ringe Corrosion. Et nærmere Studium af de levende Individers Skaller vil iøvrigt frembyde ganske de samme Faser i Ødelæggelsesværket som dem, man kan paavise for Skalbæltets forlængst aflejrede tomme Skaller (Henfald af Prismelag, stødvis Opæden af Lamellag o. s. v.). Idet man imidlertid her har med en levende Organisme at gøre, hvis Eksistens afhænger af, at Eksoskelettet er ubeskadiget, opviser disse Skaller talrige Reparationsfænomener, som ikke lader sig paavise paa de tomme subfossile Skaller. Mangen en Skal bærer Vidnesbyrd om den fortvivlede Kamp, der fra Dyrets Side føres mod en eller anden Faktor — i de allerfleste Tilfælde vistnok Vandets Syremængde — som røver Kalken, ligesaa hurtigt som Dyret danner den. Hos Muslingerne, hvor Forholdene lettest lader sig iagttage, kan Dyrene, naar Kutikulaen og dermed oftest ogsaa Prismelaget et eller andet Sted oppe paa Skallen er sprængt og opløst, ikke reparere Skaden ved Hjælp af Nydannelser af disse to Lags Natur, idet Kutikula og Prismelag kun dannes af Kapperanden og ikke af Kappens hele Overflade, over hvilken netop Skaden er sket; man ser derfor heller aldrig Kutikula eller Prismelag erstattet, hvorimod Dyret søger at raade Bod paa Skaden ved at føje den ene Conchyolinlamel til efter den anden og saa vidt mulig aflejre Kalk imellem dem. Ikke sjældent iagttager man Muslingskaller, hvor Dyrene ikke længer har haft den nødvendige Kalk at raade over, og hvor tykke Marieglas-lignende Conchyolinlameller over store Stykker af Skallen er Dyrets eneste Værn mod Omverdenen. (Tavle I, Fig. 7.)

Ofte har Kutikulaen paa Limnæer og Planorber et mærkeligt afgnedet Udseende, og med Lupen kan man se den hvide Kalk skinne igennem overalt; undertiden frem-viser Skallerne dybe Furer og Gruber, dækkede i Bunden med en eneste Lamel; ja man støder ikke sjældent paa Skaller med halvdøde Dyr, hvor Skallens opløste Beskaffenhed er af den Natur, at man fristes til at tro, at man netop her maatte søge Aarsagen til Dyrets Død.

Mellem de Faktorer, der foraarsager Kutikulaens Frasprængning og rimeligvis spiller en Rolle med ved Kalkmassens videre Corrosion, fortjener Algerne en noget nærmere Omtale; jeg skal her kun henlede Opmærksomheden paa et Par Fænomener, der hidtil har været ret upaaagtede og i alt Fald ikke studerede her i Landet.

CHODAT (8) pag. 434 har paavist, at der paa endnu levende Muslingers Skaller, særlig paa de blottede Partier nær *apex,* findes grønlige Pletter, hvor Kutikulaen er hævet op: ved Snit foretagne gennem afkalkede Skaller har han iagttaget talrige Algetraade, der nærmere beskrives og afbildes; Algen kalder han *Foreliella perforans.* Disse som oftest blaagrønne Pletter er meget almindelige paa vore Muslingskaller; vel har jeg set dem paa endnu levende Dyrs Skaller, dog hyppigst paa tomme, forlængst bundfældede, der dels angribes udefra, dels fra Indersiden, hvor disse Pletter især er fremtrædende. Pletterne optræder saa vel paa Skaller fra Tjustrupsø som fra Tuelsø, Esromsø og fra Furesøen; talrigst og mest udviklede synes de at være paa de større Dybder, 8—10 Meter. Lægger man Stykker af saadanne Skaller i Pérényis Vædske, gaar Kalken bort, og Algerne bliver tilbage. Ved at skære disse afkalkede og senere farvede Stykker paa Mikrotom saa jeg, at Perlemoderlaget var gennemkrydset af talrige Algetraade; dog er det ikke lykkedes mig at faa noget Billede, der ganske svarer til de af CHODAT fremstillede, og jeg formoder, at jeg næppe har haft med den Form at gøre, som han omtaler. Naar derimod CHODAT fremhæver, at Algerne ikke synes at beskadige Skallerne synderligt, og at disse først efter lange og haarde Angreb kendeligt corroderes, gaar mine Iagttagelser ganske i samme Retning.

Meget hyppigt (Tavle I, Fig. 6) finder man levende

Eksemplarer af *Planorbis corneus* dækkede af et ganske jævnt, tilsyneladende tykt, mørkegrønt Algeovertræk, som nærmere beset er en tynd Beklædning udenpaa Skallen. Algelaget er tykkest paa Skallens ældste Partier og mangler undertiden ganske paa de yngste Vindinger. Kutikulaen er hist og her forsvunden og den hvide Kalk bleven synlig. Paa talrige Eksemplarer ser man tillige spredt ud over hele Skallen grubeformede Fordybninger, der sænker sig saa langt ned igennem denne, at al Kalken i Bunden mangler; kun et indre tyndt Lag skiller Dyrets Overflade fra Omverdenen. Ser man nærmere paa disse Grubers Sidepartier, har man øverst Algelaget, under dette Kutikulaen og dernæst de forskellige Lag i Kalken; disse viser sig paa Grubernes Sider som koncentriske Ringe. Som oftest er Bunden i Gruberne brunrød, Siderne brunlige eller hist og her hvide og det øverste Parti grønt. Paa Skaller, hvor Opløsningsprocessen er langt fremskreden, ser man Grube ved Grube adskilte ved uregelmæssige, ophøjede Partier, hvorpaa Algerne endnu er fæstede; men ogsaa her er Kutikulaen i Almindelighed fraspræengt. Gruberne, der kan naa en Diameter af 5—6 Millim., har oprindelig været sondrede fra hverandre og er af en mærkelig regelmæssig, cirkelrund Form; i de sidste Stadier smelter de sammen til store, uregelmæssige Fordybninger, indbyrdes forbundne ved mæandriske Slyngninger. I saa Tilfælde er Kalken paa store Partier af Skallen næsten bortædt, og tilbage er da kun et dybest liggende ganske tyndt Kalklag.

Hvorledes opstaar nu disse Gruber? Naar man forsigtig bortskraber Algedækket fra Skallens yngste Partier, ser man, at der i den iøvrigt friske Kutikula findes ganske fine Huller, nogle ikke større end en Naalespids, andre med en Diameter af $^1/_2$ til 1 Millimeter. Disse sidste er konturerede af en gul Ring; med en Naal kan man pille en Klump af Algemassen ud af Hullerne. Paa gamle, halvt macererede Skaller optagne fra Mosebunden finder man paa Resterne af disse Skallers gulhvide Kutikula en utallig Mængde sorte Prikker, rimeligvis svarende til Fordybningerne under det levende Algetæppe. Ogsaa de større Gruber er ofte fyldte med en mørkegrøn Algemasse.

Der synes saaledes fra dette at udgaa talrige Sænkere ned gennem Kutikulaen til den underliggende Kalk. Corrosionen af Skallen foregaar straaleformet, ligeligt til alle Sider ud fra alle de Punkter, hvor Algedækket sender Sænkere ned gennem Kutikulaen; herved opstaar da de talrige større og mindre grubeformede Fordybninger, som giver disse Skaller det før omtalte mærkelige Udseende.

At Algerne i dette Tilfælde er højst virksomme ved Corrosionen af Skallerne, derom er der næppe Tvivl. I Slammet ved Bredderne finder man de tomme Skaller aflejrede. Disse viser sig ofte gennemhullede, og med Lupen vil man kunne se, at det overalt er Bunden i de ovennævnte Gruber, der er gaaet ud; tilsidst er hele Skallen kun en gittret, gennembrudt Masse, sammenholdt af fine Kalkstrænge; naar disse brister, gaar Skallerne i Stykker og reduceres til Skalrudimenter. Hverken Vandets Syreholdighed, tilfældige Huller i Kutikulaen eller Sneglebid er i Stand til at frembringe disse regelmæssige, cirkelrunde Gruber, som jeg kun har fundet paa Skaller dækkede med det ovennævnte grønne Algeovertræk.

Det maa blive den algologiske Undersøgelses Sag nærmere at undersøge de ferske Vandes kalkborende Alger, som formentlig spiller en noget større Rolle ved Opløsningen af Molluskernes Kalkskeletter, end man hidtil har troet, og som i sig selv frembyder saa meget af biologisk Interesse. Her maa jeg nøjes med at have henledet Opmærksomheden paa Fænomenet.

Man vil formentlig i Korthed kunne sammenfatte vort Kendskab til Corrosionsfænomenerne og deres Betydning saaledes:

Corrosionsfænomenerne optræder i talrige Tilfælde allerede paa de endnu levende Dyrs Skaller.

Saalænge Kutikulaen er fuldkommen hel og ubeskadiget, sker der ingensomhelst Corrosion af

Skallen; Betingelsen for, at Corrosion skal kunne finde Sted, er, at Kutikulaen er beskadiget.

I de allerfleste Tilfælde skyldes Kutikulaens Frasprængning ydre mekaniske Faktorers Indgriben; blandt disse maa særlig fremhæves: Bundartens Beskaffenhed, Sneglebid og Algers Indflydelse. Vandets større eller mindre Syreholdighed spiller her en ganske underordnet Rolle.

Ældre Skalpartier er mere udsatte for at miste Kutikulaen end de yngre.

Aarsagen til Skallens videre Corrosion, efter at Kutikulaen er forsvunden, vil i de allerfleste Tilfælde vise sig at være Vandets større eller mindre Syreholdighed; af underordnet og mere lokal Betydning er den Indflydelse, Snegle og Alger i saa Henseende øver.

Følgerne af Corrosionsfænomenerne paa de levende Individer er, at Skallerne, naar Dyrene er døde, langt lettere dels bliver et Bytte for Vandets opløsende Egenskaber, hvorved den bundne Kalk atter overgives Søvandet, dels hurtigere falder fra hinanden og pulveriseres, hvorved Søbundens Kalkholdighed øges; ydre Forhold bevirker, om Skalaflejringerne væsentlig destrueres paa den ene eller den anden Maade.

I Skalaflejringer paa dybere Vand destrueres Skallerne rimeligvis yderst langsomt; de organiske Stoffer forsvinder, og Skallerne omdannes til en plastisk Masse, hvoraf Molluskkalken fremgaar; paa lavere Vand destrueres Skallerne langt hurtigere og, som vi skal se, paa nogen anden Vis.

Kalkaflejringerne.

Man vil af de foregaaende Afsnit have set, at der i vore Søer væsentlig gives fire forskelligartede organiske Faktorer: højere Vandplanter, Characeer, blaagrønne stenklædende Alger og Mollusker, ved hvis Virksomhed kulsur Kalk bindes og aflejres enten som Belægning uden paa Organismerne eller omgiven af organisk Materiale inden i disses Legemer. Endvidere har vi forfulgt disse Belægningers og Kalkskeletters Skæbne efter selve Organismernes Død og lært en Række Faktorer at kende, ved hvis Indflydelse Kalken atter frigøres og overgives Omverdenen. Der staar endnu tilbage at omtale de Lokaliteter, hvor den frigjorte Kalk bundfældes og aflejres, og de Bundarter, der opstaar som Følge af disse Kalkaflejringer.

Som alt bemærket i Indledningen gaar vore ferske Vandes kalkproducerende Organismer paa enkelte Undtagelser nær (Pisidier og Ostracoder) ikke synderlig ud over 11 Meter Kurven. Saafremt Kalkskeletterne alene aflejredes paa det Sted, hvor Organismerne dannede dem, maatte ogsaa de Kalkaflejringer, der skylder Organismer deres Oprindelse, udelukkende opstaa indenfor samme Kurve.

Det omgivende Medium øver imidlertid baade en kemisk og en mekanisk Indflydelse paa Kalkskeletterne, hvoraf Resultatet bliver, at en Del af den indenfor 11 Meter Kurven producerede Kalk transporteres udefter og enten aflejres paa dybere Vand eller med Afløbene føres ud af Søen.

Det vil være indlysende, at den mekaniske Paavirkning, der har Skeletternes Pulverisation til Følge, er mest intensiv overfor alle Skeletter, der aflejres paa den Del af Søbunden, som Bølgeslaget kan paavirke. Muligheden for Pulverisering foraarsaget ved Bølgeslaget vil i vore større Søer rimeligvis begynde paa 7—9 Meter og tiltage ind imod Land; de urolige Forhold i Kystbæltet vil bevirke, at det pulveriserede Materiale ikke kan aflejres herinde, men nødvendigvis føres længere udad.

Man maa endvidere formode, at ogsaa den kemiske Paavirkning er stærkere indenfor 11 Meter Kurven end udenfor denne, idet de af Planteverdenens Hefteorganer udskilte Syrer her rimeligvis vil virke Haand i Haand med Vandets egne kalkopløsende Egenskaber. Det er saaledes sandsynligt, at ret betydelige Mængder af den indenfor 11 Meter Kurven producerede Kalk aflejres udenfor Dannelsesstedet; dette lader sig ogsaa mere direkte paavise.

Da jeg ved Tuelsøs lave Bredder fandt en yppig Characeevegetation og et rigere Liv af Snegle og Muslinger, end jeg mindes at have set noget andet Sted her i Landet, tog jeg paa c. $^1/_4$ Meter Vand et Par Bundprøver umiddelbart under Characeetæpperne, hvor Bunden bogstavelig talt var dækket med Snegleskaller. Kalkmængden var imidlertid her kun 14.78 %; ude paa c. 12 Meter Vand, hvor kalkproducerende Organismer næsten ganske fattedes, viste Bundprøven derimod 59.14 %. Jeg formoder, at vi netop her har et Eksempel paa, at de inde ved Bredden dannede Kalkmængder som fint pulveriseret Kalkslam er flyttet udad og har bidraget til at øge Søbundens Kalkholdighed paa dybere Vand.

Kalkaflejringerne indenfor 11 Meter Kurven blandes i større eller mindre Grad med Bundfældninger af ganske anden Beskaffenhed; her i Landet bestaar disse væsentligt af Sand, Ler og organiske Stoffer; af disse vil Hovedmassen af Leret aflejres langt ude til Søs hinsides 11 Meter Kurven (disse Aflejringer vil derfor særlig blive omtalte i Kapitlet om Søgytje), Sandet derimod som oftest nærmest Kysten og kun, hvor særlige Lokalforhold gør sig gældende, ude paa dybere Vand. Af de organiske Stoffer vil alt det grovere Materiale fra Breddernes Vegetation aflejres paa Kysterne, navnlig hvor der er Læ for den fremherskende Vind. Ved disse Aflejringer, der bidrager til Søernes Lukning, opstaar Søbreddernes Dy- og Tørvelag (om Begrebet Strandgytje se det flg.); det nærmere Studium af disse Dannelser er af botanisk Natur; de er nøje studerede af G. ANDERSSON (om Dy, se denne). Ved Bestemmelsen af Kalkmængden i disse Aflejringer, som kun i mindre Grad vedkommer de her publicerede Undersøgelser, maa man tage Hensyn til Vandplanternes egen høje Kalkprocent i Askebestanddelen; saaledes indeholder Asken af *Nymphæa* i Følge KOHL (l. c.) 42 % $CaCO_3$ og *Elodea* 35—53 % $CaCO_3$.

Det finere pulveriserede organiske Materiale vil alt efter Pulveriseringsgraden aflejres paa dybere Vand i større eller mindre Afstand fra Kysten. Meget ofte, navnlig i lave Søer med rigt Cyanophyceeplankton, opstaar der ogsaa tæt inde under Land blaasorte, fint pulveriserede organiske Aflejringer af ganske samme Udseende og Beskaffenhed som de Dannelser, vi i det følgende skal lære at kende under Betegnelsen Cyanophyceegytje.

I de Tilfælde, hvor der sammen med Kalkaflejringerne indenfor 11 Meter Kurven finder en rigelig Bundfældning af Ler Sted, opstaar de blaagraa, hyppig noget sandblandede Jordarter, der er almindelige paa 5—8 Meter Vand i de fleste af vore større Søer, særlig Furesø, Skanderborgsø, Tuelsø, Tjustrupsø og visse Partier af Silkeborgsøerne; disse Jordarter er oftest meget rige paa organiske Aflejringer, og i de Tilfælde, hvor Søbunden er af noget fastere Beskaffenhed, saa at man kan faa den op i større Klumper, ser man, at Lag af organisk Materiale (*Fontinalis, Hypnum,* Bøgeknopskæl, Vinterknopper af *Potamogeton crispus* o. m. a.) kan veksle med kalkholdige Lerlag. For alle disse mer eller mindre urene kalk- og lerholdige Bundarter inde paa lavere Vand bør Benævnelsen Sømergel anvendes.

I Følge SENFT[1]) forstaar man ved Begrebet Mergel en saa ensartet Blanding af en eller anden Lersubstans med kulsur Kalk eller Dolomit, at der med hver enkelt Del Lersubstans er fast forbunden en Kvantitet kulsur Kalk eller Dolomit; Forbindelsen skal være saa inderlig, at Leret og Kalken ikke lader sig adskille ved mekanisk Indvirkning (Slemning), men kun ved en kemisk Proces (Syrer). Alt efter den højere eller lavere Kalkprocent opstaar de forskellige Mergelarter: mergelagtigt Ler 2—10 % $CaCO_3$, Lermergel, egentlig Mergel, Kalkmergel 50—90 % $CaCO_3$.

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[1]) F. SENFT: Die Thonsubstanzen. 1879.

Søernes Mergelaflejringer er paa den ene Side nær beslægtede med Kysternes Dy og Tørvelag, paa den anden Side med de dybere Søgytjer; alle disse Aflejringer er kun Led i samme Udviklingsrække, og der gives alle mulige Overgange mellem dem. Tænker man sig en Vandring foretaget fra Kysten udover Søbunden, vil man paa denne i alle vore dybere Søer overskride alle disse Aflejringer i lovbunden Rækkefølge; ind imod Land gaar Sømerglen over i Tørvedannelserne, ud imod Dybet i Søgytjen; Lokalforhold kan bevirke, dels at en enkelt af disse tre Bundarter viger Pladsen for en af de to andre, der i saa Fald breder sig paa den udelukkedes Bekostning, dels at de hver især kan være repræsenteret af særlige for vedkommende Lokalitet karakteristiske Dannelser. Saaledes optræder Sømerglen i sin renere Form dels som Characeekalk, dels som Molluskkalk. Begge disse Dannelser er fremkomne ved, at to kalkproducerende Faktorer, Characeer og Mollusker, har taget Luven fra alle de øvrige, og ved at de lokale Forhold har været af den Natur, at deres Aflejringer er bleven forholdsvis rene og ublandede.

Erfaringen lærer, at Characeerne naar deres yppigste Udvikling fra 4—8 Meter, og at Molluskskallerne især ophobes i et Bælte fra 8—11 Meter Vand. I Overensstemmelse hermed opstaar Molluskkalken yderst ude og Characeekalken inderst; dog synes det, som om der for Tiden kun sjældent i vore større Søer foregaar betydelige Afsætninger af Characeekalk; de urolige Forhold paa de nedadskraanende Kyster, hvor der tillige finder rigelige Bundfældninger af anden Beskaffenhed Sted, tillader ikke disse Aflejringers Fremkomst.

Ved Studiet af Søernes Aflejringer maa man imidlertid til Stadighed erindre, at en Sø ikke er nogen afsluttet Dannelse, men er i stadig Udvikling fra aabent Vandbassin til sid Mose og tørlagt Eng. Under denne Udvikling skifter Livsvilkaarene og dermed ogsaa Søens Flora og Fauna. I

Søens Historie indtræffer Organismernes Optima i lovbunden Rækkefølge; Characeernes indtræffer først, naar Søbunden er højnet saa stærkt, at de kan brede sig ud over denne. ɔ: naar Dybden (hos os) ikke overskrider c. 8—10 Meter. Naar Forholdene iøvrigt er gunstige dannes da de store Characeeskove, som vi senere skal omtale; de skraanende Kyster er jævnede, et fladt Plateau er til Stede, hvor Aflejringerne kan finde Sted, og først da opstaar Characeekalken. Paa samme Maade forholder det sig ogsaa med Molluskkalken, men da denne opstaar paa dybere Vand og altsaa under roligere Forhold, kan denne Dannelse fremkomme endnu, medens Søen er et stort aabent Vandbassin.

Idet vi forbigaar de urene Sømergler, nærmest fordi vi endnu intet kender til vore større Søers Dy- og Tørveaflejringer, skal vi nærmere gaa ind paa de ovennævnte Søkalkaflejringer: Characeekalken og Molluskkalken.

A. Characeekalken.

1. BRAND. Ueber die Vegetations-Verhältnisse des Würmsees und seine Grundalgen. Botan. Centralbl. 45. 1896. p. 1.

2. FOREL, F. A. La faune profonde des lacs Suisses. Nouv. mémoires de la Soc. Hélvetique des sciences naturelles. 29. 1885.

3. LAMPERT, K. Das Leben der Binnengewässer. 1899. p. 471.

4. KERNER, A. v. Pflanzenleben. 1890—91.

5. KLEBAHN und LEMMERMANN. Vorarbeiten zu einer Flora des Plöner Seengebietes. Forschungsber. aus der biolog. Station zu Plöen. 3. 1895.

6. KOHL, F. G. Anatom. physiolog. Untersuchungen der Kalksalze und Kiselsäure in der Pflanze. 1889.

7. + LYELL. On a recent formation of fresh water limestone in Forfarshire. Transact. Geolog. Soc. 2. 1829. p. 73.

8. MAGNIN, M. A. Recherches sur la végétation des lacs du Jura. Revue générale de Botanique. 5. 1893. p. 241.

9. MIGULA, W. Die Characeen Deutschlands, Oesterreichs und der Schweiz. Rabenhorsts Kryptogamen-Flora. 2. Aufl. 1897.

10. + PIETERS, A. J. The Plants of Lake St. Clair. Bull. Michigan Fish-Com. 2. 1894.

11. + REIGHARD, Y. E. A biological examination of lake St. Clair. Bull. Michigan Fish-Com. 4. 1894.

12. Rostrup, E. Lollands Vegetationsforhold. Vidensk. Medd. nat. Foren. 1864. p. 1. (Sep.)

13. Seward, A. C. Fossil Plants. 1898. 1. p. 69 og p. 222—228.

14. Schröter, C. og Kirchner, O. Die Vegetation des Bodensees: Der Bodensee-Forschungen. 9. Absch. 1896. (Sep.)

15. + Sharpe, S. On a remarkable incrustation in Northamptonshire. Geolog. Mag. 5. p. 563. 1868.

16. + Skertchly, Y. The geology of the Fenland. Mem. Geol. Survey. 1877.

17. Thompson, H. D. Report on the Plants. Appendix I in: a biological examination of lake Michigan. Bull. of the Michigan Fish-Commission. 6. p. 72. 1896. (Sep.)

18. Ward, H. B. A biological examination of lake Michigan in the Traverse bay region. Bull. of the Michigan Fish Comm. 6. 1896. (Sep.)

19. Zeiler, R. Eléments de Paléobotanique. 1900. p. 36—37.

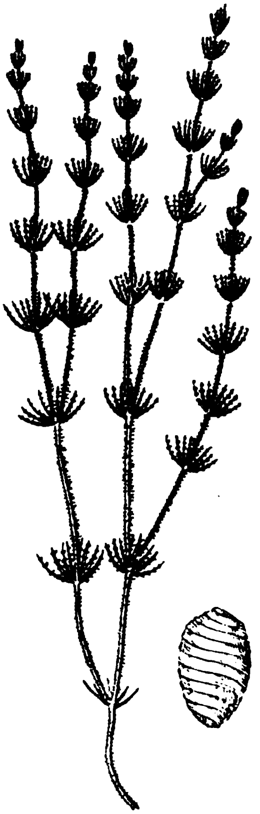
Da jeg havde erfaret, at der i Hingesø i Hinge Sogn, omtrent en Mil Sydost for Landsbyen Kjellerup, fandtes betydelige Aflejringer af »Sømergel«, som var Genstand for Indvinding, lagde jeg i Sommeren 1900 paa min Jyllandsrejse Vejen om af Landsbyen Hinge. Ved Hr. Pastor Langes og de to Mergelgravere d'Hrr. Jens og Anders P. Madsens Velvilje og Imødekommenhed fik jeg Lejlighed til at komme ud paa en af de store Flydebroer midt i Søen, hvorfra Merglen opgraves. Under mit Ophold optoges der Prøver af Mudderet og de øverste Mergellag; senere tilsendtes der mig, efter min Anmodning, Prøver fra de nedre og de under Merglen liggende Jordlag, og det blev mig saaledes muligt at skaffe udførligere Oplysninger om disse interessante Aflejringer.

Søen, der er c. 3 Kilom. lang, er næppe noget Sted synderlig over 4—5 Meter dyb, de fleste Steder betydelig mindre. Bunden bestaar øverst af et Lag Mudder, hvis Tykkelse varierer fra c. 10 Centimeter til over 1 Meter; under dette og gaaende jævnt over i samme ligger en, navnlig i sine nederste Partier, noget presset Tørv, hvis Tykkelse er meget forskellig. I Mudderet fandtes et stort Antal af levende *Unio,* enkelte *Anodonta* samt *Valvata piscinalis,* sidstnævnte særdeles talrig; derimod var *Limnæa* og *Bithynia* herude forholdsvis sjældne. Skalmængden i Tørven var ringe, enkelte Kitinflager fra Muslingernes Kutikula kunde derimod paavises. Jo dybere man kom ned i Tørvemassen, desmere graalig blev den, indtil den efterhaanden gik over i den rene Mergel. Denne, der efter Mergelgravernes Udsagn strakte sig 2—3 Meter i Dybden, var af en graablaa, i sine øverste Partier noget mørkere Farve, grovere i de øverste Lag og tiltagende i Finhed nedefter; iøvrigt havde den, naar Forskellen i Materialets Finhed undtages, helt igennem samme Struktur. Under Merglen laa en stærkt presset, kalkholdig Tørv. Cand. HARTZ, hvem jeg herved bringer min Tak, har undersøgt de over og under Merglen liggende Tørvelag; efter hans Udsagn kunde der ikke paavises Forskelligheder i Vegetationsaflejringerne over og under Merglen.

Behandler man en Prøve af Merglen fra de øverste, umiddelbart under Tørven liggende Lag i Sigteapparatet, vil en betydelig Del gaa igennem dette; paa øverste Sigtebund bliver der en Del Eksemplarer af *Bithynia,* enkelte af *Limnæa* og *Cyclas* tilbage. Valvaterne er sjældne, og Merglen viser ikke en eneste Rest af *Anodonta* eller *Unio;* paa de to nederste Sigtebunde efterlades derimod et stort Antal hule, cylindriske Stykker af ulige Længde, dog sjældent over $^3/_4$ Centimeter og af blaagraa Farve; nærmere beset viser det sig, at Ydersiden er nopret og ru, ofte stribet af c. 14—16 Længdefurer, paa Indersiden er de derimod glatte. Ganske lignende Stykker havde jeg flere Aar i Træk i Foraarstiden set i Opskyllet paa Furesøens Bredder og havde her haft Lejlighed til at iagttage, at de fremkom ved Sønderdeling af løsrevne Characeer, naar disse i Brændingen rullede mod Breddens Sten og Sand.

Betragter man nøjere en halvtør Mergelklump fra det øverste Lag, ser man, at den væsentlig bestaar af disse Rør, der ligger spredte og sammenkittede i en fin, blød Masse af samme Farve som Rørene. De øverste og mellemste Partier af Merglen indeholder alle mulige Overgange mellem de c. 1 Centim. lange Kalkrør og de fint pulveriserede, ukendelige Smaastykker. I Merglens nedre Partier aftager

Antallet af Kalkrørene, og dybest nede er Massen saa fint pulveriseret, at det hele endog gaar igennem en Sigte af Møllergaze Nr. 17; disse underste Lags oprindelige Bestanddele er man altsaa ude af Stand til at paavise. Da Merglens Farve og Struktur imidlertid er ensartet, og Overgangen fra de fint pulveriserede nedre Lag til de øverste med Kalkrørene vel bevarede lader sig paavise overalt, er der ingen Tvivl om, at disse Lag fra øverst til nederst har ganske samme Oprindelse. Idet der endvidere ikke kan være nogen Tvivl om, at disse Kalkrør hidrører fra Characeer, er Søkalken i Hingesø altsaa opstaaet ved Bundfældninger af de Hylstre af kulsur Kalk, der i højere eller ringere Grad afsættes udenom disse Planter; den Rolle, som Molluskernes Kalkaflejringer spiller med Hensyn til Dannelsen af denne Mergel, er absolut Characeernes underlegen; med Rette betegner vi Søkalkaflejringerne i Hingesø som Characeekalk.


En *Chara* i naturlig Størrelse. Tilhøjre en Spore forstørret. (Frem: Danske Stat, Sp. 211.)

Ved nærmere at studere de bedst konserverede Characeestykker ser man let, at der i alt Fald kan sondres mellem to Slags: den ene bestaar af et simpelt, hult Rør med glatte Indervægge og ikke særlig stærkt noprede Ydervægge; Tværsnittet af et saadant Rør præsenterer sig kun som en simpel Ring; den anden er af mere kompliceret Natur; Tværsnittet viser nemlig her en større Ring omgivet af et noget forskelligt Antal, 10—20 smaa Ringe. Ved at sammenholde det Billede, dette Tværsnit frembyder, med Kalkrørenes Udseende fra Siden, forstaar man endydermere, at der udenom det større Rør cirkelformet er ordnet et Antal andre med mindre Diameter.

Hovedmassen af Characeerne er udenom Centralcellen beklædt med en Belægning af et forskelligt Antal Barkceller; denne Beklædning mangler dog paa de yderste Grenspidser og paa Bladene; de to forskellige Slags Rørstykker hidrører derfor muligvis fra forskellige Dele af samme Plante.

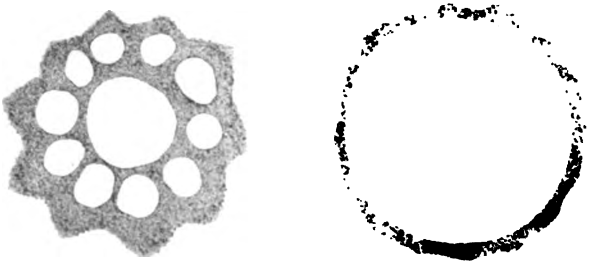


Fig. 3. Tværsnit af to subfossile Charastængler; den ene med Mærkerne af Barkcellerne udenom Centralcellen, den anden dannet af en simpel Ring.

Characeerne deles iøvrigt i to Underfamilier *Chareæ* og *Nitelleæ;* af disse afviger Nitelleerne fra førstnævnte bl. a. ved ganske at mangle Barkceller; den simple Rørtype kunde derfor muligvis ogsaa hidrøre fra Planter af Nitelleernes Gruppe. Skønt Nitelleernes svage Kalkbelægninger paa Forhaand gør det usandsynligt, at de skulde opbevares i genkendelige Rørstykker, maa jeg dog formode, at en Del af Hingesøs Characeekalk virkelig er dannet af Niteller. Dels ligner nemlig de overalt lige vide Rør af den simple Type ikke Charabladene, der gærne er tilspidsede i alt Fald i den ene Ende, dels og navnlig har jeg fundet store Stykker af Characeekalk alene dannet af Rør af denne

Type; dette lader sig ikke forklare, saafremt vedkommende Stykker var dannet af Characeer hørende til Gruppen *Chareæ;* i Stykker, der væsentlig bestod af den komplicerede Rørtype, fandtes altid mellem disse talrige af den simple Type; hvorvidt de formentlig af Niteller dannede Partier af Kalk har tilhørt de dybere Lag i Kalkaflejringerne, ved jeg ikke.

I god Overensstemmelse med, at *Chara*-Stykkernes anatomiske Bygning saa nøje lader sig konservere, staar det ovenfor omtalte Forhold, at i alt Fald en Del af de til Slægten *Chara* hørende Arter aflejrer Kalk i Skillevæggene mellem Barkceller og Centralcellen. Ved en nærmere Undersøgelse af Kalkstykkerne og det ikke ringe Antal *Chara*-Frugter, som findes i Characeekalken, vilde det rimeligvis være muligt at bestemme de *Chara*-Arter, der har dannet denne. Det bør fremhæves, at disse Frugter altid er kalkinkrusterede i Modsætning til *Chara*-Frugterne fra Moserne, hvoraf ofte kun de brune Hylstre er tilbage.

En Prøve af Characeekalken viste, at den indeholdt ikke mindre end 88.50 % $CaCO_3$. At Characeerne virkelig kan danne Jordarter med en saa høj Kalkprocent og over forholdsvis saa betydelige Arealer, som her rimeligvis er Tale om, lader sig uden Vanskelighed forklare ud fra Kendskabet til den levende Plantes Kalkprocent og Voksemaade. Saaledes indeholder *Chara foetida* efter KOHL (6) pag. 10 ikke mindre end 95—96 % $CaCO_3$.

Da jeg i Juli 1900 lærte Characeekalken i Hingesø at kende, vidste jeg ikke bedre, end at jeg her havde fundet nye og hidtil ukendte Kalkaflejringer. Ved Gennemgang af Literaturen viste det sig, at saadanne Aflejringer allerede før var fundne; alt tyder paa, at Characeerne ved Dannelsen af Ferskvandskalken og særlig Søkalken spiller en langt større Rolle, end man før har antaget og endog i tidligere Perioder. Deres Forhistorie er i Korthed følgende. Characeerne gaar (SEWARD [13] pag. 225) muligvis tilbage endog til Devon, de er kendte sikkert fra Jura (SEWARD pag. 225, ZEILER [19] pag. 36) og er hyppige i Oligocen. I prætertiære Jordlag er de, saa vidt vides, hidtil kun fundne som Sporer; i tertiære, men ganske særlig i posttertiære Aflejringer medvirker de i ikke ringe Grad ved Dannelsen af Kalkstenene. Travertinen ved Cannstadt i Württemberg og ved Burgtonna i Thüringen skal saaledes i Følge MIGULA (9) pag. 28 bl. a. skylde Characeerne sin Oprindelse.

Aflejringer af Characeekalk, der foregaar endnu den Dag i Dag eller i alt Fald for nylig er afsluttede, beskrives af LYELL (7) fra Forfarshire og af SHARPE (15) fra Northamptonshire. Sidstnævnte har ved Udgravning af en udtørret Bugt hørende til en større Sø fundet talrige velkonserverede Planter, under- og overlejrede af pulveriserede Kalkmasser. SKERTCHLY (16) angiver, at man i Moserne har fundet Kalkaflejringer som hvide Striber, der for en stor Del skal være dannede af Characeer. Da denne her citerede Literatur desværre ikke har været mig tilgængelig, kan jeg ikke gaa nærmere ind paa disse Fund.

Endelig omtaler FOREL (2) pag. 217, at der i Lac de Joux findes en halv Snes Høje, der midt ude i Søen hæver sig fra 20—25 M.s Dybde lige op til Vandspejlet. Overfladen af disse Høje dannes af et »craie blanche« fremkommen ved Bundfældninger af Characeernes Kalkhylstre. Lignende isolerede characeebevoksede Bakker hæver sig ude i flere af vore større Søer. Saaledes finder man midt ude i Furesø paa 25—30 M. Vand to Bakker, der hæver sig op til 4—5 M. under Vandspejlet; jeg formoder, at saadanne Bakker skyldes naturlige Hævninger i Søbunden, der senere er bleven beklædte med Characeer, ved hvis Aflejringer Bakkerne yderligere højnes; en Gang i Tiden vil disse blive til Øer. I den lille Slaaensø nær Silkeborgsøerne har man meddelt mig, at der findes lignende Bakker, hvis Bund angives at være »kridhvid«; det var mig desværre umuligt at komme ud paa Søen og faa disse Bakker undersøgt.

Fra botanisk Side har KERNER (4) I, pag. 240 formodet, at Characeerne kunde bidrage mægtigt til Aflejringerne af Ferskvandskalk.

Dannelsen af Characeekalken i Hingesø er rimeligvis foregaaet paa en Tid, da Søen var i det mindste noget dybere, end den for Øjeblikket er. Den har paa det Tidspunkt været dækket af et rigt ensartet Characeetæppe uden synderlig Iblanding af andre Planter. Under de rolige Forhold i klart, rimeligvis stærkt kalkholdigt Vand har Aflejringen af de sønderbrudte *Chara*-Stængler uhindret kunnet foregaa. Dannelsen er vistnok nu i alt væsentligt ophørt; i større Mængde findes Planterne i alt Fald ikke for Øjeblikket i Søen. Paa det Tidspunkt, da Characeerne havde højnet Bunden saa meget, at Breddens Plantevækst kunde rykke ud over hele Søen, og *Potamogeton, Myriophyllum* o. a. kunde fæste Rod omtrent overalt, kom Kampen til at staa mellem denne nye Vegetation og Characeerne; i denne Kamp er sidstnævnte bukket under. Den ny Vegetation aflejrede sine henraadnende Partikler over Characeekalken, først iblandet med Affaldet fra den hendøende Characeeflora (den graa, kalkholdige Tørv), senere ublandet (det sorte, øverste Tørvelag). Samtidig skabtes der Betingelser for et mere udbredt Molluskliv, og de af Søens Mollusker, der kunde gaa længst ud, *Unio, Anodonta, Bithynia, Valvata,* spredtes over hele Søen, og deres Skaller aflejredes i Mængde i Slammet.

Flere af vore Søer befinder sig for Øjeblikket netop paa det Stadium, hvorpaa Hingesø befandt sig den Gang, dens Bund var dækket med Characeer. Hele den store Bugt af Furesøen, der betegnes ved »Store Kalven«, og som kun er 3—5 Meter dyb, er for Øjeblikket overdækket med et frodigt, pragtfuldt Tæppe af *Tolypellopsis* og forskellige *Chara*-Arter, som kun endnu lader et Bælte midt i Bugten nogenlunde frit. Dette Tæppe, der i klart Vejr direkte lader sig iagttage, fortjente i høj Grad en nærmere botanisk Undersøgelse. Bunden er graalighvid, og ved nøjere Undersøgelse finder man, at den ganske som i Hingesø bestaar af utallige mere eller mindre pulveriserede Charastykker. Aabenbart foregaar der her en ganske lignende Kalkaflejring som i sin Tid i Hingesø, kun vil rimeligvis *Elodea,* der mere og mere tager Overhaand, forurene Kalkdannelsen en Del. Ogsaa den endnu fladere, gennemgaaende kun 1$^1/_2$ til 2 Meter dybe Gentoftesø forholder sig formentlig paa noget lignende Vis. Hist og her findes spredte Characeebevoksninger, der dog rimeligvis efterhaanden fortrænges af *Myriophyllum, Ceratophyllum* o. a. Om der i Bunden finder Characeekalk-lignende Dannelser Sted, ved jeg ikke, da det ikke er lykkedes mig med Skraben at naa tilstrækkelig langt ned gennem den nuværende Vegetations Mudderaflejringer.

I Tørvemoser og Damme med Tørvebund har jeg tit haft Lejlighed til at undersøge Bunden under den der voksende, ofte meget yppige *Chara*-Vegetation. Aflejringerne af Characeerne synes her at forholde sig paa anden Vis. Under Characeepuderne ligger nemlig et graaligt Slam, stærkt blandet med Tørvemudder. I dette Slam kan man ikke paavise Spor af de enkelte *Chara*-Stykker, men det hele bestaar af en henflydende, ildelugtende Masse, hvori Kalken efter al Sandsynlighed opløses af Humussyrerne; Forholdet vil rimeligvis stille sig anderledes i Mergelgrave, der synes at afgive et særlig yndet Voksested for Characeerne (Rostrup [12] pag. 12—13).

Den fra Hingesø stammende Characeekalk er meget søgt som Jordforbedringsmiddel. Det er i denne Sammenhæng ikke uden Interesse, at man i Følge Migula (9) pag. 395 i Tyskland ikke sjældent opfisker Characeerne af Søerne, kører dem paa Markerne og anvender dem som Gødning. Denne Fremgangsmaade skal allerede have været i Brug ved Bodensøen 1784 og finder endnu Sted, om end i mindre Grad end tidligere; ogsaa i denne Form skal Characeerne afgive et ganske udmærket Gødningsmiddel.

I alle de af mig undersøgte Søer standser Characeerne paa 8—9 Meter Vand. Indenfor 5 Meter danner de Underskoven under Kystens Fanerogamflora, udenfor 5 Meter gør *Fontinalis* og i sjældnere Tilfælde *Elodea,* der endnu kan træffes paa 10 Meter (Furesøen), dem Eneherredømmet stridigt. Saa vidt min Erfaring rækker, dominerer dog Characeerne i alle vore større Søer saa vel over *Fontinalis* som over *Elodea;* i mindre Søer, særlig med humussyreholdigt (brunt) Vand, er Bunden derimod meget ofte dækket med store sammenhængende Tæpper af *Fontinalis,* som her rimeligvis om Vinteren spiller en meget stor, men endnu ukendt Rolle for overvintrende Organismer (Snegle, Midder o. a.). For Jurasøernes Vedkommende meddeler Magnin (8) pag. 306, at Kransalgerne gaar ud til 13 Meter. I Starnberger- og Müggelsee fandt Brand (1) dem omtrent paa samme Dybde, i Bodensøen naar de ud til en Dybde af c. 30 Meter (Schröter og Kirschner [14] pag. 21), i Genfersøen til c. 25 Meter (Forel [2] pag. 71), i Ploenersee (Klebahn og Lemmermann [5]) til c. 4 Meter, i Lac de Joux til 10 Meter (Forel [2] pag. 217), i Pine Lake nær Michigansøen gaar Characeerne efter Thompson (17) p. 72 ligeledes ud til c. 7 Meter; samme Grænse angiver Reighard (11) for Lake St. Clair ligeledes i Nærheden af Michigansøen. Hyppig finder man angivet, at Nitellerne af alle Characeer gaar længst ud og danner et særligt Bælte udenfor de til Slægten *Chara* hørende Arter, der i de mindre Søer i Almindelighed angives at standse ved c. 7 Meter; hvorvidt der i vore Søer findes et lignende særligt *Nitella*-Bælte, maa blive en botanisk Undersøgelses Sag nærmere at paavise, saa vel som at bringe yderligere Oplysninger til Veje om Grænserne for de enkelte *Chara*-Arters Udbredning udadtil imod Dybet. Om Afhængighedsforhold mellem Characeernes bathymetriske Udbredning og Vandets Klarhed findes Oplysninger hos Magnin (8) pag. 311. Som alt ovenfor berørt synes det, at der i Characeezonen, hvorved forstaas den Zone, der ligger mellem Fanerogamfloraens og Characeernes yderste Grænser, ikke foregaar nogen særlig betydelig Aflejring af Characeekalk; Grundene hertil er angivet ovenfor; muligvis foregaar dog saadanne Aflejringer lokalt i vore større Søer, f. Eks. ud for Nørreskov i Furesøen. Større Aflejringer af Characeekalk vil formentlig først opstaa paa et temmelig sent Tidspunkt i Søens Historie.

B. Molluskkalken.

1. BRANDT, A. Von den armenischen Alpenseen. Zoolog. Anzeiger. 2. 1879. pag. 522.

2. + CLESSIN, S. Molluskenfauna von Österreich-Ungarn und der Schweiz. Nürnberg. 1887. Citat efter Surbeck.

3. — Die Mollusken der Tiefenfauna unsere Alpenseen. Malacozoologische Blätter. 24. 1877. pag. 159.

4. FOREL, F. A. La faune profonde des lacs Suisses. Nouv. mémoires de la société Hélvetique des sciences naturelles. 29. 1885.

5. + IMHOF, O. E. Zoologische Mitteilungen. Vierteljahrsschrift der Züricher naturf. Gesellschaft. 30. 1885. Citat efter Surbeck.

6. JOHANSEN, A. C. Bidrag til vore Ferskvandsmolluskers Biologi. Vidensk. Medd. fra den naturh. Forening i Kjøbenhavn. 1899. (Sep.)

7. PAULI, A. Ueber die Wasserathmung der Limnäiden. Gekrönte Preisschrift. München. 1877.

8. SURBECK, G. Die Molluskenfauna des Vierwaldstättersees. Dissert. 1899. (Sep.) Revue suisse de zoologie.

Ved Skrabning i Furesøens Bund (Sommeren 1899) blev det konstateret, at Molluskskallerne ikke laa jævnt spredte ud over hele Søbunden. Naar Skaller af Pisidierne fraregnedes, var Antallet af de øvrige Molluskskaller allerede udenfor 15 Meter Kurven meget ringe; paa 20—30 Meter Vand bragte Skraben kun undtagelsesvis enkelte Eksemplarer op. Saasnart man derimod skrabede inde paa c. 11 Meter Vand, forandredes Forholdet ofte ret pludseligt. Skallerne kunde her ligge ophobede i forbavsende Mængder; længere inde mod Kysten i Vegetationsbæltet tog Antallet atter kendelig af, navnlig i Bæltets øverste Del, nærmest Strandbredden samt paa Steder, hvor Vegetationen var meget frodig.

Ved Undersøgelsen (Sommeren 1900) af alle de førnævnte større jyske og sjællandske Søer viste det sig, at disse for Furesøen fundne Forhold var typiske og konstante for alle vore større Søer med Dybder paa over 14—15 M. Hovedmassen af Molluskskaller aflejres overalt paa Dybder mellem 8—11 M. Vand; udenfor c. 15 M. Kurven er Antallet som oftest forsvindende; indenfor c. 7 Meter Kurven forholder de enkelte Søer sig ikke paa samme Vis, da Muligheden for større Skalaflejringer afhænger af en Række ydre Faktorer (Søbreddens Heldningsvinkel, Bundarten, Vegetationen, Vindforholdene o. s. v.), som netop indenfor 7 M. Kurven virker paa meget forskellig Vis i de forskellige Søer.

Man kan dog som Regel sige, at der i alle ovennævnte Søer langs Kysten ude paa 8—11 Meter Vand strækker sig et Bælte, hvori Hovedmassen af Søens Molluskskaller aflejres; jeg betegner i det følgende dette Bælte som Skalbæltet.

Hvori søger vi nu Aarsagen til, at Hovedmassen af Søens Molluskskaller aflejres paa denne Maade, og at et Skalbælte opstaar? Hvad er da Aarsagen til Bæltets Begrænsning udadtil? Nærmere Undersøgelser har vist, at de forskellige Søers Skalbælter overalt fremkommer ved Bundfældning af væsentlig de samme Molluskarters Skaller. Saaledes træffer man Skallerne af *Unio, Anodonta, Pisidium, Valvata piscinalis* hyppig i Varieteten *antiqua*[1]), *Bithynia tentaculata, Planorbis albus* samt noget sjældnere af *Neritina;* Skallerne af Limnæerne, de større *Planorbis*-Arter. *Paludina* er derimod sparsomt og som oftest aldeles ikke repræsenterede; kun i Skanderborgsø fandtes paa c. 7—8 Meter Vand et Par mindre Banker meget rige paa *Limnæa ovata.* I alle de hidtil undersøgte Søer har Skallerne af Anodonter, Unier og Valvater altid været de talrigste. I Tjustrupsø og Haldsø dominerede Muslingerne; i Mossø og Julsø samt Viborgsøerne i Almindelighed Valvaterne. I Furesø og Esromsø kunde Skalbæltet undertiden indeholde utrolige Mængder af de sidstnævntes Skaller.

Skaller af Bithynier forekommer i visse Partier af Skalbæltet sjældent helt saa hyppigt som af Valvater; i Furesøen synes de dog at være omtrent lige talrige. Planorbernes Skaller spiller overalt en underordnet Rolle.

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[1]) Fra de mindre Arter *V. macrostoma* og *cristata* ser vi i det følgende bort.

Angaaende de enkelte Molluskskallers Fordeling indenfor selve Skalbæltet kan det i Almindelighed siges, at Skaller af *Unio* og *Anodonta* endnu træffes lidt nedenfor Bæltet c. 11—13 Meter; Bithyniernes er væsentlig kun hjemmehørende paa Bæltets Top c. 8 M.; Valvaternes Skaller synes derimod at være spredte over hele Bæltet, men er dog talrigst ved Toppen.

Undersøger man nærmere det sigtede og indsamlede Materiale, viser det sig, at Molluskllivet i Skalbæltet ingenlunde er ganske uddødt. Endnu paa 13 Meter støder man paa levende Anodonter; Hovedmassen standser dog allerede ved 11 Meter; *Unio* gaar næppe helt saa langt som *Anodonta.* Udenfor 13 Meter har jeg i vore Søer, naar Pisidierne undtages, aldrig stødt paa en levende Mollusk; disse spreder sig derimod over vore dybeste Søbunde og synes endog her at forekomme med større Individantal end i selve Skalbæltet.

Af Snegle finder man levende *Valvata piscinalis,* dog ikke udenfor 8—9 Meter, Bithynierne og de smaa *Planorbis*-Arter naar derimod knapt saa langt ud; begge Slægter standser øjensynlig der, hvor Characee- og Fontinalistæpperne ophører; alle de øvrige Former: Limnæerne, de større *Planorbis*-Arter, *Paludina, Neritina* er i vore Søer absolut ikke hjemmehørende paa saa store Dybder. Vel kan man undtagelsesvis faa en *L. auricularia* eller *ovata* op fra 7—8 Meter, men Hovedmassen af alle ovennævnte Former opholder sig inde paa lavere Vand. Til disse Iagttagelser over Molluskernes bathymetriske Udbredning i vore større Søer maa dog knyttes den Bemærkning, at Undersøgelserne altid er foretagne om Sommeren; efter al Sandsynlighed foregaar der om Vinteren en Udvandring fra Kysten til dybere Vand (A. C. Johansen [6] p. 155), og jeg anser det derfor for tvivlsomt, om de ovenfor angivne Grænser for Molluskarternes Udbredning udadtil ogsaa har Gyldighed for Vinterhalvaaret.

Af de her givne Meddelelser om Molluskernes Udbredelse over Søbunden vil man for det første forstaa, at Skalbæltets Begrænsning udadtil simpelthen beror paa, at Molluskerne med ovennævnte Undtagelse i vore Søer ikke gaar ud over 11—13 Meter; der, hvor Mollusklivet standser, aflejres ogsaa Hovedmassen af Skallerne; paa disse ret betydelige Dybder findes der ingen almenvirkende, udadførende Kraft, der er i Stand til at sprede Kalkskeletterne videre ud over Søbunden; de enkelte Skaller, der undertiden bringes op fra de større Sødybder, modbeviser ikke denne Sætnings Almengyldighed.

Ud fra det Faktum, at der i Skalbæltet væsentlig kun findes Skaller af saadanne Mollusker, som endnu lever derude (Muslinger, Valvater, Bithynier) eller i alt Fald ved Bæltets Grænser, men ikke af saadanne, der lever indenfor samme og nærmere Kysten (de fleste Planorber, Limnæer, *Neritina*), vil man endvidere forstaa, at Skalbæltet opstaar ved Bundfældning af de i samme levende Molluskers Skaller, og at der fra Kysten ikke føres væsentlige Mængder af Skaller ud i Bæltet.

Mod denne Opfattelse taler ved første Øjekast det mærkelige Misforhold, som findes mellem de faa levende Individer og de uhyre Mængder af tomme Skaller. Ofte kan man ved en eneste Skrabning faa flere tusinde tomme Skaller af *Valvata piscinalis* op, medens der selv ved nøje Gennemsyn af Materialet næppe lader sig opdrive c. 50 levende Valvater; lignende, men dog ikke helt saa grelle Misforhold, gør sig gældende, hvad Muslingerne angaar; de enorme Masser af tomme Skaller gør det ved første Øjekast utænkeligt, at Skalbæltet væsentlig skulde være opstaaet ved Bundfældning af Skaller fra et saa ringe Antal Individer.

Dog maa man erindre, at store Aflejringer lige saa vel kan opstaa ved langsom Bundfældning gennem lange Tidsrum som ved Massebundfældning i korte; hvad det ved Dannelsen af vore Skalbælter væsentlig kommer an paa er, at Forholdene, hvorunder de opstaar, er rolige og nogenlunde ensartede hele Aaret, samt at Bundarten egner sig til Opbevaring af Kalkskeletter; er disse to Betingelser til Stede, bliver det en Sag af ganske underordnet Betydning, om der i Skalbæltet paa et givet Tidspunkt er en stor Mængde eller kun et forsvindende Antal kalkproducerende Organismer til Stede.

Der er selvfølgelig ingen Tvivl om, at en stor Del af Skallerne fra Characeebæltets yderste Grænser faktisk føres de faa Meter ud i den øverste Del af Skalbæltet: derimod kan der næppe være Tale om en mere almindelig Aflejring af Kystens Molluskskaller paa dybere Vand, dels fordi disse for en meget væsentlig Del pulveriseres, og derfor ikke naar Skalbæltet som hele Eksemplarer, dels fordi man, hvis dette virkelig var Tilfældet, vilde være ude af Stand til at angive nogen Grund til, at Skallerne i saa Fald ikke spredtes ud over hele Søbunden. Dette Spørgsmaal hænger imidlertid sammen med andre af ren hydrografisk Natur, vedrørende de forskellige ind- og udadførende Strømme i vore Søer; angaaende dette Punkt skal jeg kun bemærke, at man ved Studiet ude i Naturen snarere danner sig den Opfattelse, at Strømbevægelsen fører Skaller fra Dybet og aflejrer dem inde paa Kysten end omvendt.

Vi gaar dernæst over til at betragte Aarsagen til Bæltets Begrænsning ind imod Land; man maa dog straks tage det Forbehold, at Begrænsningen indefter ikke er nær saa skarp som ud imod Dybet. Undertiden er Aflejringen af Skaller lige saa betydelig inde paa lavere Vand som ude paa 9—11 Meter; i de allerfleste Tilfælde tager dog Skalmængden meget kendelig af ind imod Land, og dette er særlig Tilfældet overalt, hvor en frodig Vegetation dækker Søbunden, hvorimod Skalaflejringerne fortsætter sig indad paa de nøgne Pletter i Vegetationsbæltet[1]); dog er Forskellen i Skalmængden paa nøgne og paa bevoksede Pletter i Vegetationsbæltet næppe saa stor, som det alene af Skrabningerne synes at fremgaa, da Skraben altid vanskeligere gaar i Bund, hvor der er rig Vegetation, end hvor Bunden er bar.

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[1]) Fra et botanisk Synspunkt vilde det vel være naturligt at sondre Vegetationsbæltet ud i flere Zoner, saasom *Chara-Fontinalis*-Zonen, *Potamogeton lucens*-Zonen og *Scirpus-Phragmites*-Zonen, der alle mer eller mindre skarpt lader sig paavise i vore større Søer; her behandles de dog under et og betegnes som Vegetationsbæltet.

Det er ganske utvivlsomt, at Antallet af levende Mollusker i vore større Søer i alt Fald i Sommerhalvaaret, er langt betydeligere saa vel hvad Individ- som hvad Artsantal angaar indenfor end ude i selve Skalbæltet. Hvorledes forstaar man da det mærkelige Forhold, at Mængden af tomme Skaller desuagtet er mindre i Vegetationsbæltet end udenfor dette?

Vegetationsbæltets Molluskfauna indbefatter først og fremmest ganske de samme Arter som Skalbæltets. *Unio* og *Anodonta* graver deres Gange indtil paa c. $^1/_2$ Meters Dyb. *Valvata piscinalis* er talrigst repræsenteret i Bæltets yderste Del; indenfor c. 2—3 Meter tager Antallet i Almindelighed af; Bithynierne findes spredte over hele Bæltet, men Hovedmassen holder sig i Almindelighed nærmere Kysten end Valvaterne. Neritinerne tager, i alt Fald i Sommertiden, gradvis til ind imod Bredden, og den største Mængde synes at opholde sig indenfor ca. 1 Meter Vand.

Desforuden og hovedsagelig karakteriseres Vegetationsbæltet dog af *Limnæa* og *Planorbis,* af hvilke Flertallet baade af Individer og Arter standser langt indenfor Skalbæltet. Af disse gaar *L. palustris* og *truncatula* saa vel som *Planorbis corneus* og *umbilicatus,* for saa vidt de findes i Søen, næppe synderlig udenfor Søens moseagtige Vige. *L. stagnalis* har jeg kun undtagelsesvis faaet op udenfor *P. lucens* Bæltet (c. 5 Meter). Længst ud gaar *L. ovata* og *auricularia,* der endnu paa 6 Meter er ret talrige paa Characeevegetationen, men som dog sjældent følger denne ud til dens yderste Grænser.

De her givne Oplysninger om Molluskernes bathymetriske Udbredelse støtter sig til Undersøgelser, der i Sommeren 1899 foretoges i Furesøen sammen med *cand. mag.* A. C. JOHANSEN; senere hen har jeg selv foretaget yderligere

Skrabninger i Furesøen og desforuden i de ovennævnte Søer. Molluskfaunaen er i dem alle mærkelig ensartet, og de Grænser, hvortil de enkelte Arter gaar ud, synes noget nær at være de samme i alle Søerne. Mere indgaaende Undersøgelser, der alene havde til Opgave at udrede Molluskernes bathymetriske og faunistiske Udbredelse, vil naturligvis kunne fiksere disse Grænser skarpere og paavise Uoverensstemmelserne i de forskellige Søer; detaillerede Undersøgelser af denne Art har dog ligget udenfor dette Arbejdes Plan, men vilde iøvrigt være meget ønskelige.

Undersøger man nærmere Maaden, hvorpaa alle disse forskelligartede Molluskers Skaller aflejres i Vegetationsbæltet, lægger man Mærke til, at en betydelig Forskel gør sig gældende i Henseende til de forskellige Arter. Hovedmassen af Skallerne af Muslinger, Bithynier og Valvater aflejres nemlig udenfor 2 Meter Vand; herude træffer man forholdsvis faa Skaller af Limnæer, Planorber og Neritiner, der aflejres paa Strandbredden, hvor de skylles op af Bølgerne. Forfølger man førstnævntes videre Skæbne, vil man se, at Skallerne, navnlig i alle de Tilfælde, hvor Aflejringen er foregaaet i og under rig Vegetation, herinde undergaar en hurtig Opløsning; Kutikulaen er ofte stærkt beskadiget, men navnlig udmærker Flertallet af Skallerne sig, hvad A. C. Johansen først iagttog, i høj Grad ved at være tyndslidte; herved afviger de kendelig fra de tilsvarende ude i Skalbæltet.

En langt skarpere Omdannelse foregaar dog med de langs Strandkanten aflejrede Skaller. Medens man om Sommeren ved Bredden af vore større Søer i Almindelighed kun finder et forholdsvis ringe Antal Skaller, stiger Mængden allerede efter de første stærke Efteraarsstorme, men er dog størst, lige naar Isen er gaaet af Vandet, og Foraarsstormene har dannet de ofte alenhøje Volde af henraadnende Vegetation og alt det andet Opskyl, der i de første Foraarsdage aflejres paa beskyttede Partier af den Kyst, mod hvilken Stormen har raset. Ved Tjustrupsø, Tuelsø, Esromsø og til Dels Furesø har jeg i April—Maj iagttaget disse meget betydelige Skalaflejringer, ganske særlig af *Limnæa* og *Planorbis,* men ofte ogsaa af *Neritina, Bithynia,* undtagelsesvis af *Valvata* og i endnu ringere Grad af *Unio* og *Anodonta.* Det synes, som om der i Foraarstiden navnlig ved de større Søer finder en almindelig Bortdøen Sted af større (ældre) Snegle; man træffer nemlig et stort Antal døende eller henraadnende gamle Snegle skvulpende i Bølgeslaget udenfor Opskyllet eller aflejrede i dette; paa et vist Trin af Forraadnelsesprocessen skylles alle bløde Dele ud af Skallerne, svulmer geleagtigt op og runder sig af til Gelekugler ofte med en Diameter paa 7—8 Centim. I April 1898 iagttoges saaledes ved Furesøen en hel Bræmme af disse Gelekugler. En Del af de tomme Skaller aflejres af Bølgerne saa højt oppe paa Land, at de ikke senere gribes af disse, men Størsteparten skvulpes af Bølgerne mod Stenene, knuses og findes senere aflejrede som Brudstykker paa indtil 1 Meter Vand; saadanne Skalaflejringer kan man f. Eks. iagttage paa Søndersøs sydøstlige Kyst. Som oftest gaar dog Pulverisationen videre for sig, og i visse Søer, f. Eks. Tuelsø og Maglesø, dannes der i Forsommeren paa Brændingskysten et hvidgult yderst fint pulveriseret Kalkslam, der efter Storm farver Vandet mælkehvidt (iagttaget i Maj 1899), og som, naar dette igen er roligt, rimeligvis aflejres ude paa dybere Vand (se ovenfor).

Man vil nu forstaa Aarsagerne til, at en Begrænsning af Skalbæltet ind imod Kysten fremkommer. Alle de skalpulveriserende Faktorer: det stærke Bølgeslag, den ujævne Grus- og Stenbund, henover hvilken de tomme Skaller ruller, bevirker en hurtig Pulverisation af Skallerne, og de urolige Forhold tillader ingen Aflejring af det pulveriserede Materiale. Alle de skal-korroderende og kalkopløsende Faktorer: Syrerne fra Planternes Hæfterødder, kalkborende Alger, det større Individantal af Mollusker, kort sagt hele det rige og mere uensartede organiske Liv, der har hjemme i Vegetationszonen, fremkalder yderligere talrige Skallers Korrosion og fuldstændige Opløsning. De i Vegetationsbæltet herskende Naturforhold tillader ikke større Skalaflejringer; disse kan først finde Sted paa roligere Vand udenfor Vegetationen.

Idet alle de skalopløsende Faktorer ikke stanser ved en og samme Grænse, er Skalbæltet i Almindelighed heller ikke særlig skarpt begrænset ind imod Land, omend Grænsen ogsaa her i mange Tilfælde meget vel lader sig paavise. Ganske særlig synes Vegetationen i saa Henseende at øve en betydelig Indflydelse. I de Tilfælde, hvor Characeetæpperne stanser forholdsvis brat, er Begrænsningen af Bæltet indadtil ogsaa skarpt markeret; i de Tilfælde derimod, hvor Skraben udenfor det egentlige Bælte stadig bringer mer eller mindre betydelige Rester af Characeer med, vil skarpe Grænser for Skalbæltet indadtil heller ikke kunne paavises.

Idet de enkelte Zoner i Vegetationsbæltet, saa vidt mig bekendt, staar mere skarpt adskilte paa stejle end paa jævnt skraanende Kyster, vil det i mange Tilfælde være Kystens Heldningsvinkel, der bestemmer Skalbæltets Begrænsning indadtil saa vel som sammes større eller mindre Afstand fra Land.

Det synes, som om man ikke tidligere har haft Opmærksomheden henledt paa, at der ved Molluskernes Virksomhed i en vis Afstand fra Land opstaar et skalførende Bælte. Aarsagen hertil har rimeligvis været den, at man overhovedet kender grumme lidt til Molluskernes bathymetriske Udbredelse; denne er mig bekendt kun undersøgt for Vierwaldstättersøens Vedkommende. De Resultater, som Surbeck (8) fra denne Sø har bragt for Dagen, stemmer nøje overens med de, der nu foreligger fra de danske Søer. Udenfor 20 Meter har Surbeck (pag. 481), naar Pisidierne undtages, ingensinde faaet levende Mollusker op. Desværre giver Forf. ingen Oplysninger om Najadernes bathymetriske Udbredelse; han indskrænker sig (pag. 467) til at bemærke, at de »sich in einen Tiefe von 3—4 m. in ausgedehnten, üppigen Charawiesen verlieren«; af Sneglene gaar Valvaterne længst ud og er endnu taget levende paa 20 Meter. Limnæerne er ligesom i de danske

Søer overalt Kystformer, men nærmere Angivelse af de yderste Grænser for deres Udbredelse udadtil gives ikke. Aflejringen af tomme Skaller er ikke nærmere undersøgt; dog meddeles det (pag. 457), at tomme Skaller ude paa større Dybder (udenfor 15 Meter Kurven) kun fandtes hist og her i faa Eksemplarer, men at saadanne paa en enkelt Lokalitet dog var fundne paa c. 100 Meters Dybde; endvidere omtaler han nu og da større Muslingbanker, der dog ikke nøjere lod sig undersøge. For Genfersøens Vedkommende angiver Forel (4) (pag. 143), at Skallerne paa de store Dybder kun findes i et Antal *peu considérable;* i Zürichersøen har han derimod kunnet paavise *leur abondance* endnu paa 80 m.

Overalt, hvor man med Skraben har undersøgt de større Søers Dyb, har man kunnet konstatere, at Pisidierne spreder sig over meget store Sødybder (300 M.), og at de herude er repræsenterede med et stort Individ- og ikke ringe Artsantal. Om de øvrige Formers bathymetriske Udbredelse lyder Beretningerne forskelligt; for Genfersøen angiver som bekendt Forel (4), at Limnæerne gaar ned til c. 260 M., og at de optræder i Bæltet fra 50 til 260 M. med særlige Arter; Brandt (1) angiver, at han i Goktschai-Søen i Armenien har taget Limnæer paa c. 80 M., og Pauly (7) har fanget *L. auricularia* i Starnbergersøen paa en Dybde af 50—80 M. I Følge Imhof (5) gaar forskellige Paludiner i Gardasøen ned til 60 M., Valvaterne i Følge Clessin (2) samme Steds ned til 90 M. og i Genfersøen til 100 M. (3). Om den Talrighed, hvormed disse Former optræder ude paa Dybet, savner man endnu nøjere Oplysninger. Nærmere at gaa ind paa det lidet, man ved om Molluskernes Udbredelse i større, udenfor Europa liggende Søer (Bajkalsøen, de store afrikanske og nordamerikanske Søer) er her formentlig ikke Anledning til; kun skal det fremhæves, at Lortet i Følge Forel (4) (pag. 221) har taget Unio paa mellem 50—100 M. i Tiberiasøen.

Det er for Furesøens Fiskere en velkendt Sag, at der langs med de fleste af Furesøens Kyster i nogen Afstand fra Land ligger en Række mindre Fiskebanker; de fleste forekommer paa 8—12 Meter Vand, altsaa i Skalbæltet. Enkelte af dem er saa høje, at Toppen kun ligger 4—5 Meter under Vandspejlet; meget ofte er de beklædte med *Potamogeton lucens* og *perfoliatus*, hvis kraftige Skud allerede i nogen Afstand røber Bankernes Nærværelse. Disse Bankers Bundart er en graablaa, i tørret Tilstand hvidgraa Søkalk, ofte indeholdende Skaller i umaadelige Mængder (Valvater, Anodonter og Unioer). Saavel ind imod Land som ud til Siderne falder Dybden fra 4—5 ned til 7—12 M.; paa Ydersiden sænker de sig jævnt ned mod Sødybet. Ganske tilsvarende Fiskebanker finder man i Skanderborgsø beliggende i en Bræmme langs Kysten, men adskilt fra denne ved dybere Vand; ogsaa her ligger Bankerne i Skalbæltet paa 7—12 M. Vand, og Afstanden fra Bankens Top til Vandspejlet er ogsaa her 4—5 M. Bundarten er for disse Bankers Vedkommende ligeledes en blaagraa Søkalk, undertiden indeholdende endnu større Skalmængder end Furesøbankerne. Tilsvarende Banker langs Kysten har jeg søgt i Tjustrupsø, Silkeborgsøerne og Haldsø, men uden Resultat.

Der er vel en Mulighed for, at Bakkekæderne i Furesø og Skanderborgsø skyldes Forhøjninger i den oprindelige Søbund, men den Mulighed er dog heller ikke udelukket, at de opbygges af Molluskerne og fremkommer ved Aflejring af Skaller. Saafremt de bundhøjnende Faktorer ikke virker med ensartet Styrke over hele Søbundens Overflade, maa Bakker opstaa overalt, hvor Aflejringerne under i øvrigt rolige Forhold foregaar med større Intensitet. Jeg skønner derfor ikke rettere, end at Mollusklivet under de rolige Forhold, der hersker i Skalbæltet, netop virker som en saadan stærkt lokaliseret, bundhøjnende Faktor, hvortil der i alt Fald uden for 11 Meter Kurven ikke gives noget tilsvarende. Nærmere Undersøgelser i større og dybere Søer end de danske maa afgøre, om man i Virkeligheden kan tilskrive Molluskerne en vold- eller revbyggende Virksomhed.

Hvad Skalbæltets Beliggenhed i Søen angaar, maa det erindres, at denne i Søens Historie selvfølgelig ingenlunde er konstant, men at Bæltet tværtimod stadig flytter sig udefter og i Tidens Løb ligesom ruller hen over Søbunden. Idet Søen lukker sig, forskydes de yderste Grænser for Molluskernes Optræden længere og længere bort fra den oprindelige Kystlinie. Naar det Tidspunkt da er kommet, hvor Søens Maksimaldybde er svundet ind til 11—14 Meter, er der ikke længere Tale om noget egentlig Skalbælte, idet Molluskerne paa dette Tidsrum staar i Begreb med at erobre hele Søbunden. Dette er t. Eks. for Øjeblikket Tilfældet med store Partier af Sondersø og Gentoftesø, hvor man kan støde paa store Aflejringer af Molluskskaller spredte over hele Søbunden.

Den Jordart, man som oftest træffer i Skalbæltet, er en blaagraa, mer eller mindre ren Søkalk, som ved Tørring antager en hvidgraa Farve; den er selvfølgelig rig paa Skaller af de ovennævnte Mollusker, hvis Antal undertiden er saa stort, at der egentlig ikke bliver Tale om nogen Jordart, men kun om Ophobninger af Skaller. Som ovenfor omtalt er disse meget ofte her af en kridtagtig, plastisk Beskaffenhed; kunde man lægge et Tværsnit gennem Bæltet, vilde man i større eller mindre Afstand fra Overfladen rimeligvis altid finde et Lag, hvor Skallerne var af denne Beskaffenhed. — Den blaagraa Sømergel ude i Skalbæltet, hvis Skalmængde og Kalkprocent kan stige saa højt, at Betegnelsen Molluskkalk er fuldt berettiget, opstaar uden al Tvivl ved Skallernes Henflyden og Omdannelse til Kalkslam.

Ikke sjældent finder man, at den blaagraa Søkalk over lange Strækninger i Skalbæltet afløses af et blaasort, stinkende Dynd; dette er saaledes Tilfældet i Mossøs vestligste Del, i forskellige Partier i Julsø og ud for Landsbyen Tjustrup i Tjustrupsø. Ud for Nørreskov i Furesø er Skalbæltets Bundart brun til brunsort; saadanne Bundarter opstaar ved rigelig Tilblanding af organisk Materiale. Dette stammer i Julsø væsentlig fra Planktonets Cyanophyceer, i Furesø fra Affaldet fra Nørreskov, hvis Knopskæl, Grene, Blade etc. paa Grund af de stærkt skraanende Kyster her aflejres paa forholdsvis dybt Vand.

For Furesøens Vedkommende har jeg kunnet vise, at de ovennævnte Banker aldrig opstaar i de Dele af Skalbæltet, hvor Bunden er rig paa organiske Aflejringer, men kun forekommer, hvor Bundens Farve er blaagraa. Undersøger man endvidere Beskaffenheden af Skallerne, viser det sig, at disse corroderes langt stærkere i de sorte end i de blaagraa Bundarter; dette var navnlig fremtrædende i Skalaflejringerne i Haldsø og Julsø, hvor jeg fik Indtrykket af, at Skallerne, overalt hvor de bundfældes i blaasort Dynd, ætses og opløses. I saa Tilfælde finder der næppe nogen Pulverisation af Skallerne Sted, og der fremkommer altsaa heller ingen Kalkaflejringer. For nu saa godt det lod sig gøre at konstatere dette, tog jeg en Bundprøve fra saadanne Steder i Skalbæltet, hvor Skallerne laa særlig tæt, men hvor Bunden var sort Slam. Kalkprocenten i Slammet var paa saadanne Steder for Julsøs Vedkommende lig 0, for Haldsøs Vedkommende 0,4 %. Heraf synes det at fremgaa, at en af Betingelserne for Molluskkalkens Aflejring er, at Tilblanding af organiske Stoffer ikke maa være for rigelig; hvor dette er Tilfældet, bevirker nemlig den med de stærke organiske Omdannelsesprocesser forbundne Syredannelse, at Kalken opløses.

Kap. 2. Om Forekomsten af Brunjernsten, særlig i Form af Bønnemalm.

1. van Bemmelen, J. M. Les accumulations ferrugineuses dans et sous les tourbières. Gissement, composition, formation. Archives Néerlandaises des sciences exactes et naturelles. Ser. II. 4. 1900.

2. Molisch, H. Die Pflanze in ihren Beziehungen zum Eisen. Eine physiologishe Studie. Jena 1892.

3. Senft, F. Die Humus, Marsch, Torf- und Limonitbildungen. 1862.

4. Stapff, F. M. Ueber die Entstehung der Seerze. Zeitschr. d. Deutschen geolog. Gesellschaft. 18. 1866. pag. 86.

5. Winogradsky, S. Ueber Eisenbakterien. Botan. Zeitung. 48. 1888. pag. 261.

6. Wolney, E. Die Zersetzung der organischen Stoffe. 1897.

Da jeg for allerede 3 Aar siden begyndte at skrabe i Furesøens Bund, var den mærkelige Omdannelse, som Hovedmassen af Skalbæltets Molluskarter blev underkastet et af de Fænomener, som særlig tiltrak sig min Opmærksomhed. Flere Steder fik man, ved at lade Dyndet passere et Sigteapparat, dette fyldt af en Masse sorte, kuglerunde Legemer, sjældent større end en Ært eller mindre end et Knappenaalshoved. Samtidig fandtes et noget mindre Antal uregelmæssige, pladeformede Stykker fra 2—3 Centimeter i Kvadrat og ned til kun faa Millim. Størrelse. Ved Tørring blev Stykkerne brunrøde. Der var ingen Tvivl om, at jeg her havde stødt paa ret betydelige Aflejringer af Bønnemalm, en Dannelse, som tidligere ikke var fundet her i Landet. Særlig interessant blev Fundet derved, at det indsamlede Materiale i alt Fald gav nogle Bidrag til Forstaaelsen af en af de Maader, hvorpaa Bønnemalmen opstaar.

Medens man nemlig særlig ved Senfts (3) og Stapffs (4) Undersøgelser har nogen Kendskab til Maaden, hvorpaa de øvrige Former for Limonit (Mosemalm, Myremalm, Kildemalm, de svenske og finske Sømalme o. a.) dannes, synes det, som om den særlige Form for Limonit, der betegnes som Bønnemalm, og som i Følge Senft særlig opstaar i Søer, men dog ogsaa (pag. 171) paa Ager og Eng, ikke nærmere er bleven undersøgt.

I 1888 paaviste Winogradsky (5), at der gaves Bakterier analoge med Svovlbakterierne, som optager Jærnforilte, ilter dette og efter Oxydationen atter udskiller det som Jærntveiltehydrat, der i betydelige Mængder aflejres i Skederne. Disse Bakterier kaldte Winogradsky Jærnbakterier og formodede, at de mægtige Limonitaflejringer i Form af Mosemalm, Sømalm, »Wiesenerze«, »Raseneisenstein« o. s. v. efter al Sandsynlighed opstod som Følge af disse Bakteriers Virksomhed. Senere hen, 1892, har Molisch (2) hævdet, at disse Jærnbakterier ikke, saaledes som Winogradsky mener, ubetinget fordrer Jærnforilte til deres Trivsel; da han endvidere ved at undersøge »34 Raseneisenstein« kun i to af disse kunde paavise Jærnbakterier, antager han, at disse ved Dannelsen af Limoniten ikke spiller saa stor en Rolle, som Winogradsky formodede.

Da Forf. mangler Kompetence til at afgøre, hvilken af disse Opfattelser, der er den rette, skal der i det følgende kun fremsættes en Redegørelse for Bønnemalmens Optræden her i Landet; men da Undersøgelsen tillige har givet det uventede Resultat, at Malmen i vore Søer for en væsentlig Del synes at fremkomme ved en Omdannelse af Molluskernes Skaller, har jeg, saa vidt muligt, studeret denne Omdannelsesproces noget nærmere. Fremtidige Undersøgelser over større Landomraader vil alene kunne godtgøre, om Molluskskallerne ved Dannelsen af Bønnemalmen virkelig spiller saa stor en Rolle, som man efter Iagttagelser her i Landet nødvendigvis maa formode.

Som tidligere omtalt, er den i Skalbæltet hyppigst forekommende Snegleskal: *Valvata piscinalis.* Paa visse Partier i dette Bælte er Skallen hvid, men som oftest præsenterer den sig mer eller mindre brunsort; ved Tørring antager den en rødbrun Farve. Ved nærmere Undersøgelse af Materialet finder man (Tavle 2, Fig. 16—29) mange Skaller, hvor den hvide Farve er fuldstændig skjult af Jærnet og Furerne mellem Vindingerne tilmed helt udfyldte af dette, saa at Stykker fremkommer, som kun røber deres oprindelige Natur ved, at Skalmundingen endnu er bevaret. Endelig finder man saadanne Former, hvor ogsaa Skalmunden fyldes af Jærnet, og Resultatet bliver i saa Fald et kegledannet Legeme, hvis Form alene lader ane, at Jærnklumpen skjuler en Snegleskal. Men idet nu Jærnudskillelsen skrider videre, fremkommer tilsidst en fuldkommen regelmæssig Kugle, et typisk Stykke Bønnemalm. Skærer man en saadan Kugle igennem, finder man yderst et Antal koncentriske Lag af Jærn, indenfor dem i nogle Tilfælde et hvidt Lag, Rester af Snegleskallen, og inderst en kulsort Masse, det af Jærnet gennemtrængte Dynd, som oprindelig udfyldte Snegleskallen. Andre Kugler viser ikke Spor af Kalkhylstre i deres Indre; Jærnet omgiver her umiddelbart den sorte Kugle; Jærnskallen udenom plejer i Almindelighed at bruse for Syre og indeholder altsaa kulsur Kalk, den sorte Kugle selv bruser derimod kun ubetydeligt eller slet ikke; Kalkmængden i denne er jo direkte afhængig af Kalkholdigheden i den Bundart, hvori Skallen i sin Tid bundfældedes. Foruden disse hyppig ærtestore Kugler findes tillige talrige mindre, der alle viser samme Bygning: Yderst en brun Skal og indenfor denne en sort Kugle; direkte kan disse dog ikke henføres til omdannede Snegleskaller, om det end er sandsynligt, at de bør tolkes saaledes.

Undersøgelsen af *Anodonta* og *Unio*-Skallerne (Tavle 2, Fig. 30—35) gav et ganske tilsvarende Resultat; de ovennævnte pladeformede Stykker lod sig med fuld Sikkerhed henføre til omdannede Stykker af Muslingskaller, da alle Overgange mellem hvide, svagt brunlige og helt omdannede sorte Stykker fandtes i enhver Skrabning.

Ganske de samme Omdannelser foregaar med Bithyniernes, Neritinernes og Limnæernes Skaller, men da de to sidstnævnte (Tavle 2, Fig. 10—15) sjældent forekommer i Skalbæltet, er de Bønnemalmsstykker, der skylder disse deres Oprindelse, ogsaa sjældne. Ved Øvelse bliver man iøvrigt i Stand til at skælne Skallerne, selv paa et meget sent Omdannelsestrin; Neritinerne omdannes til Klumper. der er flade paa den ene Side, buede paa den anden og i Formen ikke ulig Kaffebønner; af Limnæerne er det særlig Skalsøjlen, den Del af Skallen, hvor Kalklaget er tykkest. som omdannes, og hvoraf svagt spiralsnoede Pinde fremkommer.

Nærmere Undersøgelser af Sømalmsaflejringerne i Furesøen gav det mærkelige Resultat, at der i det meget store Materiale, som blev bragt op, kun sjældent fandtes Stykker. der var større end *Valvata* eller *Neritina* eller som i Følge deres pladeformede Skikkelse ikke kunde afledes fra Muslingeskallerne.

Angaaende Aflejringen i Søen viste det sig, at Bønnemalmen væsentlig kun dannes i Skalbæltet og sjældnere i Vegetationsbæltet eller ude paa dybere Vand. I Skalbæltet synes Dannelsen særlig at finde Sted i den nederste Del af samme, men det var iøvrigt vanskeligt at blive klar herover. Paa visse Strækninger af Bæltet manglede Bønnemalmsdannelsen ganske, alle Skallerne var fuldstændig hvide: andre Steder var Hovedmassen mer eller mindre omdannet til Bønnemalm; uden at kunne angive den direkte Aarsag til denne tilsyneladende ganske vilkaarlige Optræden. kan jeg kun gøre opmærksom paa, at Bunden hyppig var af en mørkere brungraa Farve paa de Partier, hvor Bønnemalmsdannelsen foregik, end paa saadanne, hvor Skallerne ikke omdannes.

I Sommeren 1900 blev de fleste større danske Søer undersøgte for mulig at finde Bønnemalmen; Spor til denne fandtes i hver eneste Sø og altid i Skalbæltet; intet Steds dog i saa stor Mængde som i Furesøen; udenfor 11 Meter har jeg i disse ingensinde faaet den typiske Bønnemalm op; derimod har jeg undtagelsesvis fundet den indenfor 8 Meter; men i saa Fald har Skraben paa vedkommende Lokalitet aldrig bragt Planter med. Overalt har Bønnemalmsdannelsen væsentlig været knyttet til Molluskernes Kalkskaller og bestandig er det Valvater og Muslinger, der i saa Henseende spiller Hovedrollen. Ved at skrabe paa mange forskellige

Steder i de enkelte Søers Skalbælter blev jeg tillige opmærksom paa, at Bønnemalmsdannelsen aldrig optraadte paa Lokaliteter, hvor Bunden bestod af sort, mer eller mindre stinkende Dynd, men kun kunde paavises, hvor Bunden var stærk lerholdig, navnlig saadanne Steder, hvor den graalige Farve lod formode en temmelig høj Kalkprocent.

Medens Bønnemalmsdannelsen i Furesøen væsentlig fremkommer ved Omdannelsen af Valvaternes Skaller, opstaar Hovedmassen i Tjustrupsø ved Omdannelse af *Unio*'s og *Anodonta*'s Skaller; som Følge heraf fandtes Malmen i Tjustrupsø som større eller mindre pladeformede Stykker, paa hvilke Betegnelsen Bønnemalm egentlig daarlig passer, og som derfor i det følgende simpelthen betegnes Brunjærnsten.

Paa endnu friske Skaller (Tavle 2, Fig. 36—39) der havde bevaret deres Kutikula, fandtes hyppig 2—3 Millim. tykke, brunsorte Skorper, der strakte sig ud over større eller mindre Partier af denne. Navnlig var Skorperne tykke oppe ved Skalbuklerne og langs med Randene; de forekom især paa Oversiden, men kunde ogsaa strække sig ind paa Skallens Inderside. Efter en vis Tids Forløb syntes de fleste Skaller at brydes i større Stykker, og paa sine Steder af Søen, navnlig fra Susaaens Munding og ned langs Næsbyholms Skov fandtes i Skalbæltet en stor Mængde sønderdelte Muslingskaller, som paa Over- og Undersiden var dækkede med tykke, uregelmæssig buklede Brunjærnstensbelægninger. Undertiden bragte Skraben ogsaa hele Muslinger op, hvor i saa Fald disse Belægninger havde bredt sig ud over hele Skallen; Skallernes Midtparti manglede baade paa højre og venstre Skal (Tavle 2, Fig. 40—41), men Jærndannelserne havde strakt sig ud over Randene og kittet begge Skaller sammen, saaledes at der fremkom et ovalt Legeme, 7 Centim. langt og 4 Centim. bredt, hvor væsentlig kun Formen tydede paa, at man havde med en Musling at gøre. Oppe i Nærheden af den tidligere Skalbukkel naaede Jærnmassen en Tykkelse af to Centimeter. Sammen med disse mærkelige Brunjærnstensdannelser fandtes tillige andre uregelmæssige, flade

Stykker af ca. 4—5 Centimeter i Kvadrat; brækkede man disse over, havde man i Midten en okkerfarvet Masse, der bruste stærkt for Syrer og var omgiven af en brunsort, til Dels stærkt glinsende, lagdelt Skorpe. Den okkerfarvede Substans er formentlig den Bundmasse, som Skallerne under hele Omdannelsen til Brunjærnsten har indeholdt, og som tilsidst er bleven farvet og sammenkittet under Jærnudskillelsen; selve Muslingeskallen er repræsenteret ved den stærkt glinsende sorte Linie, der undertiden kan være dækket af uensartede, buklede, matsorte Jærnmasser, svarende til dem, man træffer uden paa de friske Muslingskaller. Intetsomhelst lader ved en første Betragtning ane, at disse uregelmæssige Stykker skylder Muslingskaller deres Oprindelse.

Ved Undersøgelsen af Valvaternes, men særlig af Muslingernes Skaller faar man væsentlig Indtrykket af, at den Proces, der under Brunjærnstensdannelsen foregaar med Skallerne, rettest kan betegnes som en Metamorfose, under hvilken den kulsure Kalk lidt efter lidt forsvinder og viger Pladsen for Jærntveiltet. For Muslingernes Vedkommende lader denne Omdannelse sig forfølge Skridt for Skridt.

Paa de yngste Stadier finder man under de tykke Jærnstensskorper paa Skallernes Overside endnu alle Skallens tre Lag: Kutikula, Prismelag og Lamellag ganske uberørte. Ved Hjælp af en Kniv skiller man let Skorpen fra den underliggende Skal; paa ældre Stadier vil man derimod, naar man brækker Skallerne i Stykker og betragter Brudrandene, se, at ogsaa Prismelaget er farvet brunsort, samt at der mellem dette og den ydre Skorpe findes en stærkt glinsende, kulsort Linie, der næppe er andet end den af Jærntveiltet imprægnerede Kutikula. Naar man paa saadanne Stykker søger at sprænge Skorperne fra, følger Kutikula og Prismelag med; set under Mikroskopet viser det sig, at sidstnævnte har bevaret sin ejendommelige parallelstribede Struktur ganske ubeskadiget. Paa endnu ældre Stadier er ogsaa Lamellaget farvet; ser man nærmere til, vil man iagttage, hvorledes dette lagvis farves ude fra indefter; selv paa ældre Stadier kan man, navnlig oppe ved Hængslet. paa meget tykke Skaller endnu paavise Konchiolinlamellerne, der adskiller de brunrøde, omdannede Kalklag fra hverandre. Paa de alleræeldste Stadier lader de enkelte Lags Struktur sig ikke paavise; ved Betragtning af saadanne meget gamle Skaller, der som oftest er belagte med tykke Skorper baade paa Inder- og Ydersiden, ser man paa det Sted mellem Belægningerne, hvor selve Muslingskallen en Gang har ligget, kun en sort, glinsende Linie.

Meget ofte har man med Skaller at gøre, hvor kun Lamellaget bruser for Syrer, hvorimod Prismelaget er saa stærkt omdannet, at det næsten ikke viser nogen Opbrusning.

Hvorvidt lignende Iagttagelser lader sig anstille paa Valvaternes Skaller, maa paa Grund af vort Ukendskab til disses Skalstrukturer henstaa uafgjort. Medens i Furesøen Omdannelsen af disse Skaller først paabegyndes længe efter at Dyrene er døde, Skallerne bundfældede i Lermassen, og Kutikulaen forsvunden, gik i Mossø de levende Valvater ude paa dybere Vand med tykke Jærnskorper udenpaa Skallerne; fra Furesø var noget tilsvarende mig ganske ukendt for Valvaternes Vedkommende.

Det Resultat, vi ved disse Undersøgelser har naaet med Hensyn til Brunjærnstensdannelsernes Optræden her i Landet, lader sig i Korthed sammenfatte saaledes.

Brunjærnstensdannelsen, navnlig i Form af Bønnemalm, optræder i de fleste af Landets større Søer; hidtil er den dog kun funden i større Mængde i Furesø og i Tjustrupsø.

Malmen opstaar hovedsagelig i Skalbæltet; kulsur Kalk, særlig i Form af Snegle eller Muslingskaller, synes at være en af Hovedbetingelserne for dens Dannelse; navnlig spiller *Valvata piscinalis, Anodonta* og *Unio* i saa Henseende en betydelig Rolle.

Omdannelsen af Skallernes kulsure Kalk til Brunjærnsten foregaar gradvis og kan, i alt Fald for Muslingskallernes Vedkommende, forfølges Skridt for Skridt.

Intet Steds har jeg i vore Søer tilnærmelsesvis fundet Brunjærnstenslag af den Størrelse og Mægtighed, der er saa karakteristisk for de svenske og finske Søer. og som der har stor økonomisk Betydning.

Hvad jeg her i Landet har set af Brunjærnsten fremkommen paa anden Vis end ved Omdannelse af Molluskskaller indskrænker sig til følgende ubetydelige Fund. Da jeg i Efteraaret 1900 i Furesøen skrabede paa et Par Steder. der ikke var bleven undersøgte 1899, fandt jeg ud for Nørreskov paa c. 11 Meter Vand noget Brunjærnsten af forskellig Oprindelse fra den ovenfor nævnte. Jærnstenen bestod nemlig her af nøddestore, uregelmæssigt formede Stykker. hyppigt runde af Form, men dog ogsaa skarpt kantede. I nogle Tilfælde lod disse Stykker sig føre tilbage til Kalksten, idet adskillige paa Overfladen var brune, men indeni hvidgraa; Overfladen bruste kun i ringe Grad for Syrer. de inderste Partier derimod meget stærkt.

I andre Tilfælde syntes Bønnemalmen at være opstaaet ved Udskillelse af Jærnet, hvor Bunden særlig egnede sig dertil. Der fandtes nemlig en Del ovale Legemer, omtrent af Størrelse som Hasselnødder; de var omgivne af en sortbrun, lagdelt ydre Skorpe, lod sig let brække over og indeholdt et mere eller mindre fast sammenhængende Pulver. Begge Steder var det Materiale, som det lykkedes mig at faa indsamlet, for utilstrækkeligt til at bygge noget nærmere paa.

Endelig har jeg fra Tjustrupsø faaet enkelte Kalksten op, som var inkrusterede med tykke Skorper af Brunjærnsten; disse Sten stammer fra Skalbæltet i c. 8 Meter Vand; fra en noget større, men ikke angiven Dybde (Esromsø) hidrører et Par større Sten med rigelige Jærnbelægninger, som den derboende Fisker velvilligt overlod mig.

Til disse Iagttagelser over Brunjærnstensdannelsen i vore Søer skal jeg til Oplysning for fremtidige Undersøgere endnu kun knytte følgende Bemærkninger angaaende Vivianiten. Det er flere Gange hændet mig, at jeg har faaet Skaller af *Valvata piscinalis* og *Anodonta* op, som enten var karakteriserede ved en dyb mørkeblaa Farve, eller som efter at have henligget nogen Tid i Luften antog en saadan. Ligeledes har jeg med Skraben faaet enkelte Sten op, som var dækkede med tykke Belægninger af Brunjærnsten, men hvoraf visse Partier var af en dyb, mørkeblaa Farve; disse Partier gik umærkelig over i den brunsorte Brunjærnstensmasse. Jeg formoder, at jeg i begge Tilfælde har haft med Vivianit at gøre; alle de hidtil iagttagne mørkeblaa Skaller og Sten stammer fra Bunddannelser, meget rige paa organiske Aflejringer; derimod har jeg ikke set noget til disse i de blaagraa, stærkt kalkholdige Søkalkaflejringer. Iøvrigt maa det blive Mineralogernes Sag videre at udnytte disse Iagttagelser. Af v. BEMMELEMS (1) Arbejde (pag. 89) synes det at fremgaa, at »la vivianite dans la plupart des cas, prenne naissance aux dépens du spath ferreux.«

Kap. 3. Om Søgytje og beslægtede Dannelser.

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Undersøgelserne af Aflejringerne paa vore dybeste Søbunde frembyder navnlig i Begyndelsen ikke ubetydelige Vanskeligheder. Bundprøverne, som Skraben henter op i de forskellige Søer, ligner nemlig ved første Øjekast hverandre i overordentlig høj Grad. De bestaar overalt af fintdelte, tyktflydende Jordarter, der kun undtagelsesvis indeholder større bestemmelige Dyre- eller Planterester (Molluskskaller, Kviste, Bøgeblade). Faunaen er noget nær den samme overalt. og kun i Farven, der veksler fra graat gennem brunt til sort, viser der sig nogen Forskel. Intet Steds har jeg stødt paa Bundarter, som ved en første Betragtning ikke meget vel lod sig benævne med de gode gamle danske Betegnelser Mudder eller Dynd.

Saasnart man derimod paabegynder en nøjere mikroskopisk Undersøgelse, hører Ensformigheden op. Man ser da, at hver Sø har sin ganske bestemte Bundart, og der rejser sig Vanskeligheder af ganske anden Natur; Benævnelserne Mudder og Dynd, der i daglig Tale i Virkeligheden anvendes for alle mørke, stærkt vandholdige og derfor mer eller mindre flydende Jordarter, viser sig at være uanvendelige i videnskabeligt Sprog, idet de betegner yderst forskelligartede Dannelser.

Det er allerede tidligere fremhævet, at Aflejringerne paa Søbunden i meget væsentlig Grad afhænger af det tilgrænsende Landskabs Jordbundsforhold og af de Jordarter, hvorigennem Søens vigtigste Tilløb skærer deres Lejer. For Danmarks Vedkommende maatte man a priori vente, at der ved Siden af udpræget organiske Bundarter maatte opstaa betydelige Aflejringer af Ler og Kalk, og jeg havde derfor formodet, at Undersøgelsen vilde bringe saavel udpræget Indsøler[1]) som ogsaa Søblege for Dagen. Det har imidlertid vist sig, at selv om vore Søbunde faktisk indeholder betydelige Mængder af Ler og ofte opviser en meget høj Kalkprocent (40—60 %), har jeg dog intet Steds stødt paa Bundarter, som med Rette lod sig tildele disse Betegnelser. Grunden hertil er rimeligvis følgende:

Overalt i vore gennemgaaende lave, varme Søer med deres jævnt skraanende Kyster og brede Vegetationszone rører der sig et meget rigt organisk Liv. Mængden af henraadnende Stoffer er overalt saa betydelig, at selv om der paa Søbunden finder rigelige Bundfældninger af Ler og Kalk Sted, tilblandes der dog disse saa store Mængder af pulveriseret organisk Materiale, at de rene Ler- og Kalkaflejringer ikke kan opstaa. Jeg formoder, at Dannelsen af Indsøleret fremkaldt ved direkte Bundfældning af Lerpartikler hører en svunden Tid til, og at man, hvis man kunde lægge tilstrækkelig dybe Snit gennem Søbunden, vilde finde dette dybt under de Lag, vi med Skraben er i Stand til at naa. Søerne paa hine umiddelbart efter Istiden følgende Tider var koldere end nu til Dags; de var endvidere dybere, Kysterne mere stejle og Vegetationszonen smallere; Søerne producerede ikke nær saa meget organisk Materiale som nu. Kommer hertil, at Floderne paa den Tid, hvad vore brede jyske Floddale tydelig bærer Vidnesbyrd om, har haft en langt større eroderende Magt end nu, og at Vegetationen, der den Gang næppe bredte sig som et sammenhængende Tæppe over Jordbunden, ikke havde den jordbindende Evne, hvorved nu til Dags Vandets udvaskende Indflydelse hæmmes, kan det med Sikkerhed formodes, at Aflejringerne af uorganisk Materiale i tidligere Tid foregik livligere end nu og mindre blandet med organiske Stoffer.

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[1]) Om denne Betegnelse se G. ANDERSSON (1) pag. 9.

Dannelsen af det ved Bundfældning opstaaede Indsøler er altsaa et svundet Led i vore Søers Historie. Saavel de talrige, over hele Landet spredte udtørrede Søbunde, som ogsaa den Hastighed, hvormed vore Nutidssøers større Vige lukker sig, er synlige Vidnesbyrd om den Udfladning af Terrainet, som i Tidernes Løb har fundet Sted og endnu til Stadighed foregaar. Vore Søer befinder sig for Øjeblikket paa Gytjestadiet, der tog sin Begyndelse, da Lerlaget var blevet tilstrækkelig tykt, og Søens organiske Liv, afhængig af dette, havde begyndt at gøre sig gældende; overalt er dog større Partier ved at gaa over i Dy eller i det tørvedannende Stadium. Kun i Mossø har jeg med Skraben fra 16 M. (Søens største Dybde angives at være ikke over 20 M.) faaet en mørkebrun Grusbund op, indeholdende betydelige Lermængder, hvoraf større Partier var sluttede sammen i Boller, som der paa Egnen gik under Benævnelsen Blaaler. Efter Fiskerens Sigende bestod Bunden overalt paa Søens dybeste Partier af Grus overlejret og blandet med Ler. Nærmere Undersøgelser maa godtgøre, om denne vort Lands største Sø med nogen betydelig Dybde virkelig endnu befinder sig paa Stadiet af Indsølerdannelsen.

Medens det saaledes uden Vanskelighed lader sig forklare, at i alt Fald disse Aflejringer af Indsøler er en væsentlig afsluttet Dannelse, er det mere ufatteligt, at Undersøgelsen ikke har kunnet paavise tilsvarende Kalkaflejringer af saa ublandet Beskaffenhed, at de kunde betegnes som Søblege; jeg formoder ogsaa, at Grunden hertil mere er en Tilfældighed, og at Fremtiden vil bringe saadanne Aflejringer for Dagen. Selv om nemlig Udvaskningen af Kalkpartiklerne fra Søens Opland og disses Bundfældning i Søen ligesom Lerpartiklernes foregaar efter en mindre Maalestok og mere iblandet med organisk Materiale end tidligere, maatte man alligevel vente, at der paa de dybere Søbunde ogsaa nu til Dags maatte opstaa Kalkaflejringer af en saa ublandet Natur, at de kunde betegnes som Søblege. Søen er nemlig i meget væsentlig Grad sin egen Kalkproducent, der i de kalkdannende Organismers Skeletter raader over betydelige Mængder af kulsur Kalk. I det foregaaende har vi omtalt de Aflejringer, der opstaar som Følge af disse Skeletters Pulverisation og lokale Bundfældning. Paavisligt foregaar der navnlig i Foraarstiden i flere af vore større Søer en Pulverisation af Lavvandets Kalkskeletter (se pag. 73), og efter al Sandsynlighed finder der senere hen en Bundfældning af disse Kalkpartikler Sted ude paa Dybet, langt uden for Dannelsesstedet (indenfor 11 Meter Kurven). Det var Aflejringer af Søblege, væsentlig fremkommen ad denne Vej, jeg havde ventet, at Undersøgelserne skulde have bragt for Dagen.

Der kan her indskydes den Bemærkning, at vi næppe ejer noget Middel til at sondre den i Søen producerede og den med Tilløbene tilførte pulveriserede Kalk fra hinanden; ja det synes endog, som om vi ikke med Sikkerhed kan skælne den mekanisk bundfældede og den af Vandet kemisk udskilte Kalk fra hinanden. FOREL har ([8] I pag. 130) tidligere beskæftiget sig med dette Spørgsmaal. Af de Oplysninger, han har samlet, synes det at fremgaa, at sidstnævnte vel undertiden kan indeholde Globulitter (Sphærokrystaller) af $CaCO_3$, men at disse dog ingenlunde altid er til Stede. Fremtidige Undersøgelser maa afgøre, i hvor høj Grad kemisk Udfældning af den i Vandet opløste Kalk bidrager til at øge Søbundens Kalkholdighed.

Kalkanalyser af Bundprøver fra 8 af vore større Søers dybeste Partier har godtgjort, dels at Kalkmængden er yderst variabel, og dels at den i adskillige Søer, hvad der iøvrigt var at vente i et Land med en saa kalkholdig Undergrund, er mærkelig høj; at drage mere vidtrækkende Slutninger ud af de fundne Tal er dog næppe tilraadeligt, da

Undersøgelsen af en enkelt Bundprøves Kalkholdighed umulig kan angive den normale Kalkprocent for vedkommende Søs dybere Bunddannelser; hertil kræves nødvendigvis et langt større Antal Analyser, end jeg har kunnet lade udføre.

Følgende Kalkprocenter er fundne:

Julsø	c. 20	Meters	Dybde	0,10	°/$_0$	CaCO$_3$
Mossø	c. 13	—	—	1,33	—	—
Haldsø	c. 40	—	—	3,00	—	—
Esromsø, nordlige Del	c. 15	—	—	14,00	—	—
— sydlige —	c. 22	—	—	14,14	—	—
Skanderborgsø	c. 15	—	—	25,41	—	—
Furesø	c. 32	—	—	35,30	—	—
Tjustrupsø	c. 20	—	—	46.98	—	—
Tuelsø	c. 12	—	—	59.44	—	—

Ingen af disse Bundarter lader sig, som man altsaa vil se. betegne som Søblege; alle maa bedst opfattes som mer eller mindre kalkholdige Gytjer, der, som vi skal se, videre lader sig inddele; de særlig kalkholdige lader sig betegne som Kalkgytjer.

Formodningen taler iøvrigt for, at hvis man kunde skaffe sig Piller af Søbunden gaaende fra Overfladen nogle Alen i Dybet, vilde man se, at Mængden af organiske Stoffer aftog nedefter samtidig med, at de mineralske Bestanddele opviste en mere ren og ublandet Beskaffenhed. I de Tilfælde, hvor Søbundens Kalkholdighed selv i de øverste Lag er 40—60 °/$_0$, ligger rimeligvis de rene Kalklag kun faa Alen under de Lag, der er tilgængelige med Skraben. Ad denne Vej foregaar som vi senere skal se rimeligvis endnu den Dag i Dag Dannelsen af Indsøler og Søblege.

Idet saaledes de øverste Lag i vore dybeste Søbundes Nutidsaflejringer paa Grund af deres Rigdom paa organiske Stoffer ikke kan betegnes som Indsøler eller Søblege, og idet Aflejringer af anden Natur hidtil ikke er funden, kan man i alt Fald for Øjeblikket sammenfatte de øverste Lag i alle vore dybere Søbundsaflejringer under en Fællesbetegnelse, for hvilken jeg i Overensstemmelse med v. Post foreslaar Betegnelsen Søgytje.

Ordet Gytje er indført i det videnskabelige Sprog af v. Post (15) og første Gang brugt i dennes fortrinlige, grundlæggende Arbejde: »Studier öfver Nutidens koprogena Jordbildningar«. v. Post forstaar ved Gytje de i rene, klare Vande væsentlig ved Bundfaunaens ekskrementerende Virksomhed opstaaede Bundaflejringer; i samme Forstand er Betegnelsen ogsaa brugt af senere Undersøgere, Trybom (22) og Gunnar Andersson (1).

Ved sit Hovedarbejde (22) samt ved senere Undersøgelser over svenske Søers Søgytje (23—26) (Søerne Noen, Hvalen, Nömmen, Bunn og Ringsjön) har Trybom yderligere bidraget til Kendskabet om Søgytjen; denne betegnes af ham med et formentlig mindre heldigt Navn som Bundgytje; Undersøgelserne er foretagne delvis med Fiskerihensyn for Øje. Trybom fremhæver særlig den store Rolle Krebsdyrene, specielt Cladocererne, spiller ved Dannelsen af Søgytjen, giver yderligere Oplysninger om Søbundens Fauna og søger procentvis at fastslaa Forholdet mellem bestemmelige og ubestemmelige Bestanddele i Gytjen.

Endelig har Gunnar Andersson ved sine ypperlige Vækst-palæontologiske Undersøgelser, hvoraf Resultater er nedlagte dels i talrige mindre Arbejder, men navnlig i de to større, »Svenska Växtvärldens Historia« (2) og »Studier öfver Finlands Torfmossar och fossila Kvartärflora« (1) ogsaa omtalt de fossile Gytjer. Idet det for disse Undersøgelsers Vedkommende i mange Tilfælde næsten bliver en Skønssag, hvor Grænsen skal drages mellem recente og fossile Aflejringer, vedkommer disse Undersøgelser de her publicerede i høj Grad; de har derfor under den videre Udarbejdelse været mig af ikke ringe Betydning, og med megen Tilfredsstillelse har jeg set, hvor stor Overensstemmelsen er mellem de Resultater, Gunnar Andersson er kommen til for de fossile Gytjers Vedkommende, og de, der er indvundne ved Studiet af Nutidens Gytjer.

For Danmarks Vedkommende har man i Almindelighed ikke sondret Gytjeaflejringerne ud fra andre Dynddannelser.

og Begrebet Gytje anvendes ikke af Danmarks geologiske Undersøgelse. Kun RØRDAM (17) har brugt denne Betegnelse og giver pag. 78—81 en Del værdifulde Oplysninger om de fossile Gytjer; særlig Interesse har hans Paavisning af disse Gytjers Rigdom paa Svovl og Kvælstof.

P. E. MÜLLER (14) har I, pag. 70, hvor disse Aflejringer ganske flygtigt berøres, misforstaaet v. POST og fejlagtig betegnet Ekskrementaflejringerne som Dy.

Vel foreligger der ret udførlige Skildringer af Bundprøver fra forskellige Schweizersøer, særlig Genfersøen (FOREL 8—10) og fra Bodensøen (BAUER og VOGEL), men dels egner Bundprøver fra Søer med Dybder paa over 2—300 M. sig ikke godt til Sammenligning med Bundprøver fra vore smaa og lave Søer, dels er Undersøgelserne fra Schweizersøerne foretagne ud fra andre Synspunkter end de, der gør sig gældende i de svenske Forskeres Arbejder, og som ogsaa lægges til Grund for de her publicerede. Det maa i høj Grad beklages, at navnlig v. POSTS betydningsfulde Værk til Stadighed forbliver et i Udlandet tilsyneladende ganske ukendt Arbejde.

Fra den store biologiske Station i Plöen, der raader over langt større Hjælpemidler end andre ferskvandsbiologiske Laboratorier og et fortrinligt Undersøgelsesomraade, foreligger endnu ikke en eneste Meddelelse om Søbunden i de af Stationen undersøgte Søer.

Materialet, hvoraf Gytjen dannes, er dels af organisk, dels af uorganisk Natur; den fremkommer først ved en Bundfældning af alle de talløse Smaapartikler, hvortil Vandmassens Vegetation og Dyreliv under de opløsende og pulveriserende Faktorers Indflydelse henfalder; dernæst ved en Bundfældning af alle de fineste uorganiske Smaadele, her i Landet navnlig Ler- og Kalkpartikler, som ved Brændingen løsnes fra Kysten, eller med Vandløbene føres ud i Søen og først stedes til Hvile under de roligste Forhold, Søen raader over; endvidere ved en Bundfældning af det paa Overfladen nedblæste atmosfæriske Støv; om dette spiller nogen synderlig Rolle hos os er vel tvivlsomt[1]). Som en fjerde, næppe uvæsentlig Faktor bør endnu en kemisk Udskillelse af de i Vandet opløste Stoffer, f. Eks. kulsur Kalk, fremhæves.

Den ad disse fire Veje opstaaede Bundart er Hjemsted for en artfattig, men individrig Dyreverden, som gennemroder Bunden, lever af den og lader den passere sin Tarmkanal. Herved omdannes Bundarten til Ekskrement, og Resultatet bliver da den som oftest graa, sjældnere rødbrune, koprogene Masse, der af v. Post betegnes som Gytje.

Jeg formoder, at Gytjen altid er en overfladisk Dannelse, der næppe strækker sig synderlig i Dybet; Bakterierne, der arbejder Haand i Haand med Dyrene, arbejder ogsaa i de underliggende Lag, som Dyrene har gennemekskrementeret; derved forsvinder Ekskrementerne i disse Lag, de tiloversblevne endnu ikke uddragne Rester af organisk Stof spaltes yderligere, og til Slut bliver der, hvis Processerne uforstyrret gaar deres Gang, kun de mineralske Bestanddele i. c. Ler og Kalk tilbage. Ad denne Vej foregaar Dannelsen af Indsøler og Søblege rimeligvis endnu den Dag i Dag; hvorvidt disse Nutidens koprogene Ler- og Kalkaflejringer lader sig adskille fra de tilsvarende glaciale Aflejringer maa Fremtiden afgøre; paa Forhaand maa man formode, at førstnævnte er noget rigere paa Humus.

Naar v. Post og senere Gunnar Andersson betegner Gytjens Farve i Almindelighed som graa, er dette rigtigt. Det maa dog bemærkes, at den ad de ovennævnte fire Veje opstaaede Fællesbundfældning paa Søbunden oprindelig næsten altid er brunsort, blaasort eller sort; rigelig Tilblanding af Ler og Kalk kan vel give en noget lysere Farve. Først ved at passere Organismernes Tarmkanal er det, at ogsaa de mørke Fællesbundfældninger bliver graa; Ekskrementer af Chironomuslarver, Oligochæter o. a. er lysere end den Bund, hvori Dyrene lever; formentlig hidrører dette fra, at Dyrene udnytter de organiske Stoffer og lader de uorganiske: Ler og Kalk, passere igennem sig.

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[1]) Tager man atmosfærisk Støv i noget videre Forstand, og regner hertil ogsaa det fygende Sand, maa man dog erindre, at dette faktisk har en stor bundhøjnende Betydning i Landets sandede Egne. Sandflugtens store Indflydelse paa Kystsøernes Bundarter, deres Vegetation og Dyreliv samt dens rent forsvindende Betydning for Landets øvrige Søer har været en af Hovedgrundene til, at jeg har udelukket Kystsøerne fra denne Undersøgelse og ment, at de burde studeres for sig.

Hovedbetingelsen for, at Gytjen kan dannes, mener jeg er den, at der er nogenlunde Ligevægt mellem tilført organisk Stof og de fordøjende Faktorers Arbejdsevne. I de Tilfælde, hvor der i Løbet af kort Tid finder mægtige Aflejringer Sted af organisk Materiale, bliver Bundfældningen ikke fuldt omdannet til Ekskrement, og Dynddannelser af anden Beskaffenhed opstaar; dette er saaledes Tilfældet med de i Floddeltaer og i mange stagnerende Damme opstaaede Dyndaflejringer; ligeledes dannes ud for Kloakmundinger Aflejringer, som af samme Grund intet har med Gytje at gøre. I de talrige Tilfælde, hvor Vandets Righoldighed paa Humussyrer hindrer yderligere Omdannelser af store Mængder af organisk, særlig vegetabilsk Materiale, opstaar der ved Humussyrernes konserverende Evne overfor alle Lignin- og kutinholdige Emner store Ophobninger af Plantestoffer, der betegnes som Dytørv (Dytorf) eller Tørv; Gytjelag opstaar saaledes ej heller i dette Tilfælde.

Den Ligevægt mellem Produktion og Konsumering af organisk Materiale, som altsaa formentlig er Betingelsen for Gytjens Dannelse, kommer i Naturen i Stand enten ved, at Bundfældningen af organisk Materiale ikke i sig selv antager for betydelige Dimensioner eller ved, at der til denne blandes rigelige Mængder af uorganisk Materiale, navnlig Ler og Kalk.

Disse Betingelser forefindes hyppigst i de rene, klare Vande, hvor, efter v. Post og Gunnar Andersson, ogsaa Gytjedannelsen særlig foregaar.

Gytjen kan iøvrigt opstaa under forskelligartede Forhold, hvorved forskelligartede Gytjer fremkommer. v. Post omtaler saaledes: »Pappergyttja, Källgyttja, Dammgyttja. Flodgyttja, Sjögyttja og Strandgyttja.« Det ligger i Sagens Natur, at der gives alle tænkelige Overgange mellem de her omhandlede Bundaflejringer; at opstille en skarp Afgrænsning mellem disse er derfor ligesaa umuligt, som den vilde være unaturlig og uberettiget. Skulde jeg dog vove en Indvending mod denne af v. Post foretagne yderligere Inddeling af Begrebet Gytje, vilde det være den, at han saaledes ind under dette Begreb fører nogle flere Bundarter end det efter hans egen Definition paa Gytje strængt taget er muligt. Netop ved at optage Aflejringer som Damgytje, der iøvrigt af v. Post selv betegnes som dyblandet Gytje, udviskes Begrebet saaledes, at det ikke lader sig holde ude fra de øvrige Dynddannelser, hvoraf netop disse Dyndaflejringer i de stærkt vegetabilske Smaadamme udgør en Del. Holder man imidlertid fast ved, at Gytje betegner de øvre Lag i de særlige Dynddannelser, der opstaar paa Bunden af rene klare Vande, ofte indeholder betydelige Mængder (c. 20—30 %) Ler og Kalk, er af koprogen Oprindelse og kun for en ringe Del bestaar af ufordøjet Materiale, da er dermed visse bestemte Dynd- og Mudderaflejringer afgrænsede som en særlig Gruppe; samtidig maa det selvfølgelig fremhæves, at der gives visse Aflejringer, der enten staar paa Overgangen til det sorte Dynd, Kloakdynd etc., eller paa Overgangen til Dy- og Tørvedannelsen.

Af de af v. Post omtalte forskelligartede Gytjer henregner jeg altsaa kun Kildegytje, Søgytje, Strandgytje, Flodgytje og maaske Papirsgytjen til Begrebet Gytje; Flodgytjen hører sikkert ogsaa herhen, men da vort Land næppe frembyder gunstige Betingelser for Studiet af denne Art Aflejringer, har jeg ikke nærmere kunnet undersøge disse. Hvad Papirsgytjen angaar, lader denne sig noget vanskeligere føre ind under den af mig foreslaaede skarpere Begrænsning af Begrebet Gytje; den er sikkert en denne meget nærstaaende Dannelse, der i Foraarstiden er almindelig over alle tidligt oversvømmede Enge, hvorfra senere hen Vandet er fordampet og har efterladt det velkendte blaagraa, soltørrede, af blaagrønne Alger, Diatomeer etc. dannede papiragtige Overtræk; smukkest udviklet har jeg i Foraarstiden set denne Gytje paa de tørlagte Engdannelser ved Sorøsø og langs Bredderne af den i Forbindelse med Sorøsø staaende Petersborgsø; iøvrigt har jeg ikke undersøgt den nærmere.

For Søernes Vedkommende mener v. Post at kunne skælne mellem to forskelligartede Gytjer, nemlig Søgytje og Strandgytje. Søgytjen er de graa eller brungraa Ekskrementaflejringer, opstaaede ude paa dybere (3—5 M.) Vand, sammensat af afbidte, kornede, graagrønne Plantestoffer iblandede med talrige, forskelligartede Dyrelevninger. Strandgytjen er de nærmere ved Kysten (fra 3—4 M. og indefter Land) opstaaede Ekskrementaflejringer, der begynder umiddelbart udenfor Nymphæaceernes og Potamogetonernes Bælte, opnaar en større Mægtighed (indtil $^3/_4$ M.) end Søgytjen og er lysere af Farve. Ogsaa disse Aflejringer dannes af Ekskrementer, og med skarpt og klart Blik for Forholdene betoner v. Post den store Andel Sneglenes, Muslingernes og Vandinsekternes Ekskrementer har i disse Aflejringers Opkomst. Utvivlsomt opholder Hovedmassen af Søens Insekter og Snegle sig netop indenfor 3—4 Meter Vand, og det er saaledes meget naturligt, at disse forholdsvis store Organismers fordøjende Virksomhed sætter sig Spor i Form af mægtigere Gytjelag indenfor end udenfor denne Zone, hvor de tilmed ikke afløses af andre ligesaa yderige Producenter. Ofte har jeg paa c. 1 Meter Vand set Bunden dækket med de let kendelige Snegleekskrementer og fundet Vandplanter, optagne paa dybere Vand, overstrøet med disse.

I Følge v. Post skal Gytjeaflejringerne opnaa deres største Mægtighed paa 2—3 Meters Dybde, men dog endnu optræde paa 3—5 M.; iøvrigt angiver han, at Laget »urtunnar sig« saavel ind imod Land som ud imod Dybet, ɔ: udenfor 5 M., der overhovedet er den Grænse, hvortil v. Post har undersøgt Søbunden. Dog anvender han i de enkelte Tilfælde, hvor han har undersøgt dybere Søbundsaflejringer (16 M.), ogsaa Betegnelsen Søgytje om disse; det er disse dybere Aflejringer, Trybom benævner »Bundgytje«; da Gytjer dannede paa lavt Vand lige saavel er Bundgytjer som de, der dannes længere ude, har jeg ikke accepteret denne Betegnelse.

Min Opfattelse af Begreberne Sø- og Strandgytje er da følgende: Den ad de fire førnævnte Veje (Side 95) opstaaede Fællesbundfældning aflejres over alle Søbundens Dele lige fra Kysten og ud til Søens største Dybder; der aflejres imidlertid ikke lige meget over hele Søbunden, ikke heller er Mængdeforholdet mellem de fire Hovedkomponenter i Fællesbundfældningen den samme overalt; Mængden af aflejret Materiale tiltager ind imod Land; ude paa Søens største Dybder anvendes der alt efter Vandsøjlens Højde Aar eller maaske Aarhundreder til at danne Lag, som paa lavere Vand naar samme Mægtighed i Løbet af Uger eller Maaneder; kun inde paa ganske lavt Vand, hvor Brændingen hindrer Aflejringernes Fremkomst, opstaar disse ikke. Hvorvidt der ude paa dybt Vand aflejres mest organisk eller mest uorganisk Materiale, samt hvorledes de fire Hovedkomponenter virker i Forhold til hverandre, derom ved vi kun grumme lidt; dog kan man formentlig gaa ud fra, at Aflejringen af organisk Materiale er større inde paa lavt Vand (i Vegetationszonen) end udenfor denne, særlig fordi Bundfældningen af Plankton og udført pulveriseret, organisk Kystmateriale ude paa Dybet næppe vejer op imod de lokale Vegetationsaflejringer og Aflejringerne fra det rigere Dyreliv i Vegetationszonen. Da Søbundens Fauna ikke er den samme overalt, bearbejdes endvidere Fællesbundfældningen ikke paa samme Vis over hele Søbunden. Idet nu Molluskerne, med Undtagelse af Pisidierne, i vore Søer standser ved c. 11 M. Kurven, og idet de dybere Søbundes Oligochæter, *Chironomus*larver og Pisidier først optræder med deres, navnlig for Oligochæternes Vedkommende, ofte uhyre Individantal udenfor denne, skønner jeg ikke rettere, end at Fællesbundfældningen paa begge Sider af 11 Meter Kurven undergaar en noget forskelligartet Bearbejdelse.

Idet vi endvidere ved, at Vegetationen i vore Søer i alt Fald gaar ud til c. 9 M., og med sine enkelte Udløbere af *Elodea* og *Fontinalis* sikkert noget længere, samt at Sneglene standser ved c. 9 M., kan vi ogsaa gaa ud fra, at der, saavel hvad Vegetationsaflejringerne som hvad Opdyngning af Snegleekskrementerne angaar, er en betydelig Forskel udenfor og indenfor 9 M. Kurven. Jeg skønner da ikke rettere, end at der, i alt Fald i vore Søer, dannes et mellem 9—11 Meter Vand beliggende Bælte, paa hvis Sider, saavel ind imod Land som ud imod Dybet, væsentlige Forskelligheder kan iagttages saavel i Karakteren af Fællesbundfældningen som med Hensyn til den Behandling, denne undergaar af Bundfaunaen. Idet jeg endvidere har Indtrykket af, at det indenfor 9 Meter Kurven er umuligt at paavise en Grænsezone, der skulde kunne skille Strandgytje- fra Søgytjeaflejringer eller at paavise de Faktorer, der skulde foranledige en saadan Inddeling, vover jeg at foreslaa, at Grænselinien mellem Strandgytjen og Søgytjen forskydes udefter til det mellem 9 og 11 Meter beliggende Bælte; hvad der ligger indenfor dette Bælte (for saavidt Aflejringerne har Gytjens Karakter), betegnes som Strandgytje, hvad der ligger udenfor som Søgytje. Det bliver en Smags Sag, om man foretrækker at lægge Grænsen ved Vegetationszonens Ophør (9 M.) eller ved Foden af Skalbæltet (c. 11 M.); jeg selv foretrækker det sidste. Af Aflejringerne indenfor og omkring 11 Meter Kurven har vi i det foregaaende lært de særlig kalkholdige Bundarter: Sømergel, Characee- og Molluskkalk, nærmere at kende; et nærmere Studium af de særlig organiske Aflejringer, Strandgytjen, hænger alle paa det nøjeste sammen med indgaaende Studier af Strandbreddens Vegetationsaflejringer. Undersøgelserne er derfor nær beslægtede med andre af rent botanisk Natur, som det maa blive andres Sag at tage op. Naar det en Gang sker, vil man sikkert se, at en Del af de som Sømergel betegnede

Dannelser paa det nøjeste er beslægtede med Strandgytje og med vore Søbredders forskelligartede Tørvedannelser.

Naar der nu efter c. 40 Aars Forløb skal gives en mere indgaaende Fremstilling af de Dannelser, v. POST betegnede som Søgytje, er det klart, at der vil være meget nyt at føje til v. POSTS Fremstilling. For 40 Aar siden var Bakteriernes Indflydelse paa Jordbund og Bundaflejringer et ukendt Problem, Begrebet Plankton eksisterede ikke, og om de dybere Søbundes Fauna bragte FOREL først c. 20 Aar senere nøjere Oplysninger. Bakteriernes Indflydelse er endnu kun lidet kendt; herom henviser jeg til det hos FOREL angivne; det er særlig med Hensyn til Planktonets og til Dels *Bundfaunaens* Indflydelse paa Søbunden, at her yderligere Oplysninger kan gives.

Kan der end saaledes bygges videre, end v. POST i sin Tid var i Stand til, maa det paa den anden Side erindres, at Fundamentet til alle disse Undersøgelser er lagt af ham.

Søgytjen lader sig, saa vidt min Erfaring rækker, afgrænse fra de øvrige Gytjeaflejringer, dels ved sin særlig store Righoldighed paa uorganiske Stoffer (hos os navnlig Ler og Kalk) samt ved at indeholde Rester af typiske Planktonorganismer. For vore Nutidsaflejringer af Søgytje kan særlig *Stephanodiscus Niagaræ, Melosira crenulata* og *granulata* samt som oftest *Asterionella gracillima* betegnes som en Slags Ledefossilier. Chitinhudene spiller i vore Søgytjer ikke den generelle Rolle, TRYBOM angiver for de svenske Søer; lokalt kan de derimod ofte optræde i uhyre Mængder.

Det har nu vist sig, at de forskellige Søers Søgytjer er af yderst forskellig Beskaffenhed; paa den anden Side er det vanskeligt at fastslaa enkelte bestemte Typer, da disse utvivlsomt vil vise sig at være indbyrdes forbundne ved alle tænkelige Overgange. Da jeg nærer den Opfattelse, at man ikke bør tilstræbe en større Precision i Fremstillingen, end selve Emnet tilsteder, om man end derved kunde bibringe Læseren en maaske noget hurtigere, men næppe fuldt saa omfattende og virkelighedstro Opfattelse, har jeg med Forsæt undgaaet en for skarp Precision af de i det følgende omtalte forskelligartede Søgytjer. Ikke sjældent er den ved ofte utilbørlig skarp Pointering opnaaede tilsyneladende Klarhed i Fremstillingen en Godtkøbsvare, der bunder i Undervurdering af Vanskelighederne eller i Mangel paa Troskab mod Naturen. Da de i det følgende omtalte Planktonundersøgelser tidlig havde givet Undersøgelsen visse Holdepunkter, som senere hen stadig har været de raadende, har jeg ogsaa valgt at lægge disse til Grund for Fremstillingen; men samtidig med, at jeg ud fra dem har opstillet visse bestemte Typer for Søgytje, har jeg tillige søgt at vise de forskellige Overgange mellem disse og paapeget Aarsagerne til, at saadanne Overgange ganske nødvendigt maa være tilstede. Idet vi nu skal gaa nærmere ind paa vore forskellige Søgytjer, vil vi særlig beskæftige os med disses organiske Bestanddele og for de uorganiske Bestanddeles Vedkommende henvise til det ovenfor sagte.

Søgytjens organiske Bestanddele har en tredobbelt Oprindelse; de stammer enten fra de tilgrænsende Landstrækningers Dyre- og Planteverden, fra Søens Littoralzone eller fra Plankton. I de forskellige Søer og paa forskellige Tidspunkter i hver Søs Historie flyder disse Kilder ikke lige stærkt. I skovomkransede lave Søer med rig Littoralvegetation vil de to førstnævnte være de mest yderige; i dybe Søer med skovfattigt Opland vil Planktonbundfældninger særlig gøre sig gældende.

Kun undtagelsesvis støder man ude paa de dybere Søbunde paa Grene eller Kviste; derimod forekommer Blade af Kystens Skovtræer ikke sjældent selv i Gytjer paa 40 M. De føres med Efteraarsstormene ud paa Vandet og bæres af Bølgerne, indtil de vandtrukne synker til Bunds. Ellers naar baade Breddernes Vegetation og den littorale Regions organiske Liv væsentlig kun de større Sødybder i pulveriseret Form. At faa et sikkert Maal for dette organiske Nedslag ude paa disse Dybder er næppe muligt; enhver Planktonundersøger vil vide, at der i Planktonprøver tagne med Møllergaze Nr. 20 altid findes ikke ubetydelige Mængder

»Snavs«: endnu større Mængder gaar sikkert igennem Nettet og ene ved Brugen af Planktonpumpen kunde man maaske danne sig et relativt Skøn over dette Nedslags Mægtighed. »Snavset« er ikke andet end det fineste pulveriserede organiske og uorganiske Kystmateriale, som føres ud over Søen og i stille Vejr langsomt synker til Bunds og kommer til Ro paa Søens dybeste Partier.

En af Betingelserne for Forstaaelsen af vore Søgytjers yderst forskelligartede Natur er et nøjere Kendskab til vedkommende Søers Plankton. Man har ved Studiet af Søgytjen taget alt for lidet Hensyn til denne Faktor, og en Redegørelse for en hel Del Forhold Plankton vedrørende vil derfor være en nødvendig Forudsætning for en nøjere Forstaaelse af vore Søgytjer.

Plankton er sammensat af et Antal yderst forskelligartede Dyre- og Plantegrupper, hvis Organisation, kemiske Beskaffenhed o. s. v. er af højst forskellig Natur. Idet snart en, snart en anden Planktonorganisme dominerer i den enkelte Sø, varierer ogsaa den kemiske Beskaffenhed af de Bundfældninger, som skylder Plankton deres Oprindelse saavel i de forskellige Søer som til forskellige Tider af Aaret i samme Sø. Det drejer sig da først og fremmest om at udrede Grundtrækkene i de enkelte Planktonkomponenters kemiske Beskaffenhed. Da Planktonorganismernes Celleindhold for Øjeblikket i alt væsentligt kun lader sig betegne som Æggehvidestoffer og Vand, og da man tilmed intet ved om Maaden, hvorpaa Æggehvidestofferne spaltes og omsættes paa Søbunden, maa vi hovedsagelig nøjes med at lære Skeletdelenes Natur og disses Betydning ved Søgytjens Dannelse nærmere at kende.

Ulemperne ved denne Begrænsning af Undersøgelsen er maaske ikke saa store, som det i Øjeblikket synes. Ved at undersøge det i vore dybe Søer nærmest Bunden staaende døde Plankton, som lige var i Begreb med at blive bundfældet og som altsaa representerede Resterne af de foregaaende Ugers Planktonsværme, har jeg set, at dette væsentlig bestaar af tomme Skeletdele; Bløddelene er enten forsvundne eller hermetisk indesluttede i Overvintringsorganernes stærkt fortykkede Kitinvægge *(Dinobryum)*, der først efter en vis Tidsfrist og ved Indtrædelsen af visse ydre Forhold atter vil aabne sig. Da jeg har iagttaget dette døde, kun af Skeletdele bestaaende Plankton ved Bunden af alle vore større og dybe Søer, synes det, som om Plankton her væsentlig kun bundfældes i Form af Skeletdele, og at Hovedmassen af Bløddelene, inden Organismerne naar Bunden, ved Bakteriers Medvirken allerede er omsat og i alt Fald ikke direkte tilføres Gytjen. I lave Søer paa c. 3—4 Meter Vand er Forholdet anderledes. Her kan man til enhver Tid af Aaret, men særlig hen paa Eftersommeren finde et over Bunden staaende, flotterende hvidgraat, raaddent Lag bestaaende af døde Dafnier, Kopepoder etc. Meget tyder paa, at det døde Plankton ude paa de større Sødybder er længe om at synke til Bunds, og det er derfor naturligt, at alle Bløddele er fortærede og omsatte, inden Organismens jordiske Levninger stedes til Hvile i Bundgytjen.

I Følge Forel (10) pag. 208 indeholder Vandmasserne i de større Søers centrale Partier forholdsvis faa Bakterier (Dutzende im Kubikcentimeter). I de fleste Tilfælde er Antallet ringere i Overfladen end i Dybet; dog foreligger der for Genfersøens Vedkommende ingen nøjere Undersøgelse over Forholdet i Vandlag under 40 M. I Følge Schröter og Kirchner (19) pag. 16 fandtes der i Zürichersøen endnu i 80 M.s Dybde 28—30 Microber, i Bodensøen i 60—65 M.s Dybde 31—146 Microber i en Kubikcentimeter Vand. Man har tidligere ment, at Overfladevandets ringe Bakteriemængde maatte tilskrives Lysets bakteriedræbende Indflydelse. Forel mener, at da Mængden af det døde Plankton tiltager nedad mod Dybet, søger ogsaa Bakterierne nedad mod de Regioner, hvor Størstedelen af de henraadnende organiske Stoffer befinder sig. Disse Opgivelser af Forel stemmer, som man vil se, godt overens med den her meddelte Iagttagelse om Bundfældning af Plankton i Form af Skeletdele (yderligere Literatur hos Smith og Weiss [21] pag. 222).

Skeletdelene af Planktonorganismerne er enten dannede af Kisel, Kitin, Kutin, Cellulose eller kulsur Kalk. Sidstnævnte Stof optræder kun skeletdannende hos ganske faa Arter, nemlig Planktonets Rhizopoder, der alle er yderst sjældne Former og endda kun findes i en meget begrænset Del af Aaret (April—Maj). Det er almindeligt, at man i Kitinskeletterne hos Leddyrene finder større eller mindre Aflejringer af Kalksalte, navnlig kulsur Kalk; ligeledes har Schilling (18) for Peridineernes Vedkommende paavist Tilstedeværelsen af Kalkforbindelser i disses Celluloseskeletter; skønt der ikke foreligger Analyser over Planktonkrustaceernes Skeletdele, er det dog, dels paa Grund af disses overordentlige Hyalinitet, dels ud fra Kendskabet til de almindelige Love, hvorefter Planktonorganismerne maa tilpasse deres Organisation, i høj Grad sandsynligt, at Kalkaflejringerne i disses Skeletdele er mindre end hos de beslægtede Former ved Bund og ved Bred. Vi kan derfor rimeligvis hos Ferskvandets Planktonorganismer se bort fra Skeletdannelser frembragte af kulsur Kalk og fra den Betydning, Kalk af denne Oprindelse maatte have ved Søgytjens Sammensætning.

Kiselsyren er skeletdannende hos Diatomeerne; disse optræder her i Landet med c. 20 Planktonarter; idet imidlertid enkelte af dem til Tider forekommer med et overordentlig stort Individantal og over lange Perioder af Aaret er saa talrige, at de ligesom maskerer alle de andre Planktonorganismer, faa de en stor Betydning ved Søgytjens Sammensætning.

Skeletdannelser frembragte af Kitin forefindes hos alle Krustaceer og Rotiferer. Af disse optræder Krustaceerne her i Landet med c. 12 Planktonarter, Rotifererne med c. 25. Trods Rotiferernes Overvægt i Artsantal er deres Betydning som Gytjedannere dog Krustaceernes langt underlegen. Aarsagen hertil ligger dels i deres ringe Størrelse, i Kitinskelettets langt større Hyalinitet, dels og fornemmelig deri, at Rotifererne netop i de større Søer kun undtagelsesvis og i hvert Fald kun i mere begrænsede Tidsintervaller optræder i saa mægtige Sværme som Krustaceerne; derimod er saa godt som alle 12 Arter af Krustaceer overalt hyppigt forekommende og optræder endog i Almindelighed i meget store Sværme.

Hvad der dog først og fremmest bevirker, at Krustaceerne faar deres store Betydning som Gytjedannere, er det store Antal Hudskifter, hver enkelt Art gennemløber. Hovedmassen af disse Hude gaar rimeligvis til Bunds; om Hudskifterne hos andre Planktonorganismer ved vi i alt Fald for Øjeblikket intet sikkert.

Ind under Kitinskeletterne bør rimeligvis ogsaa regnes de brungule Hylstre, hvormed et enkelt Infusionsdyr *Codonella lacustris* og enkelte Flagellater *(Dinobryum)* omgiver deres Legemer. Førstnævnte, hvis Hylster er meget kompakt, danner i Vintermaanederne uhyre Sværme i en enkelt af vore større Søer (Esromsø). Dinobryerne er overalt almindelig forekommende Planktonorganismer, som hyppig, navnlig i Foraarstiden, kan gøre selv større Søers Vand grødet.

Til Skeletdele (Cellevægge), dannede af Cellulose, bør rimeligvis Peridineernes Skal regnes, selv om denne ved Behandling af de til Paavisning af Cellulosen brugelige Reagenser ikke altid reagerer med den for Cellulosen sædvanlige Farve. Hos os findes c. 5 Arter som Planktonorganismer; af disse er dog knapt Halvdelen typiske for de større Søers centrale Partier, og kun een, *Ceratium hirudinella,* er i den Grad planktondannende, at den kunde faa Indflydelse paa Søgytjens Sammensætning; til Gengæld kan denne ene Art i mange Søer optræde i kolossale Mængder.

Chlorophyceerne optræder her i Landet med c. 30 Planktonorganismer; ingen af disse spiller nogen synderlig Rolle i Planktonet; de mest fremtrædende tilhører Fam. *Pediastraceæ (Pediastrum, Scenedesmus, Coelastrum)* og Fam. *Desmidiaceæ (Staurastrum);* kun *Pediastrum* og *Staurastrum* har nogen Betydning som Gytjedannere. Saa vidt vides, kender man ikke sikkert den kemiske Beskaffenhed af disse Formers Cellevægge; naturligst henregnes dog disse foreløbig under Cellulosedannelserne.

Desværre kender man ikke med Sikkerhed det Stof, hvoraf de blaagrønne Algers Cellevægge er dannede; man angiver i Almindelighed, at det er et de højere Planters Kutin nærstaaende Stof. I vore lave og varme Søer danner netop Planktonorganismerne af denne Plantegruppe som oftest Hovedmassen af alt Plankton. Af de c. 12 Arter spiller et mindre Antal en meget betydelig Rolle ved Dannelsen af Søgytjen.

Nærmere Undersøgelser har nu vist, at Mængden af de ovennævnte Skeletdele i de forskellige Søers Gytje er yderst variabel; i en Gytje dominerer Diatomeerne, i en anden Cyanophyceerne o. s. v., og man kan som Regel paavise en vis, ofte ret nøje Overensstemmelse mellem en Søs Plankton og dens Søgytjes Beskaffenhed. For da at forstaa de forskelligartede Søgytjer maa de Forhold, der foraarsager vore Søers forskelligartede Plankton, kort nævnes.

Planktonundersøgelser anstillede i næsten alle de Søer, hvorfra Søgytjer er studerede, og som støtter sig til kvartaarlige Planktonbestemmelser¹), godtgør, at man i Landets forskellige Søer noget nær i Planktonet træffer de samme Arter. I Danmark kan man ansætte Antallet af de større Søers Planktonorganismer til c. 120. Fremdeles har det vist sig, at Størstedelen af Arterne paa et hvilketsomhelst Tidspunkt af Aaret findes i vedkommende Søs Plankton. Vilde man heraf slutte, at Plankton paa et givet Tidspunkt i de forskellige Søer eller i samme Sø altid var ret ensartet, vilde dette dog være urigtigt. De forskellige ydre Faktorer, i første Instans Lys, Temperatur, Vandets kemiske Sammensætning, Vægtfylde o. a., der virker paa alt Plankton, virker nemlig med noget forskellig Styrke og paa noget forskellig Vis dels i de forskellige Søer og dels til forskellige Tider af Aaret i i samme Sø. Idet endvidere de enkelte Planktonkomponenter reagerer paa ulige Vis overfor disse ydre Faktorer, skabes der

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¹) Herom se nærmere det kommende Arbejde: Planktonundersøgelser anstillede i danske Ferskvande 1897—1901.

hverken overalt eller paa ethvert givet Tidspunkt lige gode Livsbetingelser for hver enkelt Komponent; paa Tider og Steder, hvor disse er nøjest i Overensstemmelse med vedkommende Forms Natur, tager denne Luven fra alle de øvrige Planktonorganismer og optræder da i Plankton med et ofte saa kolossalt Maksimum, at alle andre Komponenter synes helt tilbagetrængt af denne ene. Idet nu den Størrelse, disse Maksima naar, er meget variabel og indtræffer til forskellig Tid for hver Art i de forskellige Søer, opstaar saavel hvad Tid som hvad Rum angaar Variationer i Planktonets Sammensætning.

Planktonundersøgelserne har endvidere vist, at der i en Søs Plankton paa ethvert givet Tidspunkt i Almindelighed er en enkelt Dyre- eller Plantegruppe, som oftest kun ganske enkelte Arter, som dominerer og alene for sig skaber større Volumina end alle de øvrige Planktonorganismer tilsammen. Søgytjens Natur bliver derfor i meget væsentlig Grad afhængig af, hvilke Planktonorganismer der opnaar de høje Maksima i en Sø og særlig af disse Planktonorganismers Skeletdele. Mellem de c. 120 Planktonorganismer optræder over Halvdelen overalt og til enhver Tid saa overordentlig sjældent, at de ved Spørgsmaalet om Søgytjens Sammensætning er uden synderlig praktisk Betydning. Mellem den øvrige Halvdel findes derimod en Del Former, nemlig enkelte Diatomeer, Cyanophyceer, Copepoder, Daphnier samt *Ceratium hirudinella* og *Dinobryum sertularia,* der hver for sig under visse givne Forhold optræder i saa uhyre Sværme, at de derved ventelig maatte faa den store Betydning for Dannelsen af de forskellige Søgytjer.

I Overensstemmelse med disse særlig dominerende Planktontyper, hvis Skeletdele altsaa bestaar af Kisel, Kutin, Kitin eller Cellulose, maatte man i vore større Søers Bund vente at finde fire forskellige Arter af Søgytjer, væsentlig fremkomne ved Bundfældning af et af de tre førstnævnte Stoffer.

I Søer med høje Diatomeemaksima er Gytjen Diatomeegytje eller, som den i tørret Tilstand kaldes, Diatomeejord eller Mo.

I Søer med høje Cyanophyceemaksima dannes Gytjen af et blaasort, stinkende, yderst fint Slam, som betegnes Cyanophyceegytje.

I Søer med høje Maksima for kitinproducerende Organismer afsættes en graabrun, svagt ildelugtende Gytje: Kitingytjen.

En særlig Type paa Søgytje dannet ved Aflejring af Cellulose fremkommer ikke, idet Cellulosen meget tidlig spaltes og forsvinder af Søbunden.

Samtidig med at jeg opstiller ovennævnte Typer paa Søgytjer rige paa organiske Levninger, maa det straks bemærkes, at de aldrig findes absolut rene og ublandede; en Række Forhold bevirker, at der i talrige Tilfælde opstaar Blandingsgytjer; men saavidt min Erfaring rækker, synes dog Udgangspunktet for Forstaaelsen af disse rettest at bunde i de tre ovennævnte Typer. At Blandingsgytjer nødvendigvis maa opstaa, fremgaar alene af det tidligere fremhævede Forhold, at der i en Søs Plankton altid findes baade Diatomeer, kitinproducerende Organismer og Cyanophyceer. Man kan i al Almindelighed sige, at jo ringere det Antal Planktonorganismer er, som opnaar de høje Maksima i en Sø, og jo større disse enkelte Maksima bliver, desmere ensartet vil ogsaa Gytjen blive.

Desforuden gives der imidlertid talrige Forhold, der modificerer og omformer de Gytjer, som efter Planktonets Art skulde være typiske for vedkommende Sø. Blandt disse skal særlig følgende fremhæves:

1. Det er ingenlunde alt Søens Plankton eller dettes samlede Skeletmængde, der kommer til at indgaa i Dannelsen af Søgytjen. Visse Planktonkomponenter vil i de fleste Tilfælde blive aflejrede i store Mængder inde i Søens Vige paa ganske lavt Vand, andre derimod væsentlig ude paa de dybere Partier; særlige Lokalforhold eller pludselige Forandringer i Temperatur og Vindstyrke kan forrykke disse Forhold, saa at almengyldige Regler umulig kan opstilles.

De nyere Undersøgelser synes mere og mere at godtgøre, at det dyriske Plankton *(Zooplankton)* største Delen af Døgnet staar noget dybere i Vandet end det vegetabilske Plankton *(Phytoplankton)*, hvoraf en stor Hovedafdeling (Cyanophyceerne) i stille Vejr endog lejrer sig paa Overfladen og danner »Vandblomst«. Naar Vandspejlet da efter Vindstille er grønt, og en let Brise rejser sig, kan man hyppig se store Partier af Vandblomsten stribevis fejes ind mod Kysten og ved stærkere Vind aflejres paa denne; en Del gaar vel til Søs igen, naar en Fralandsvind rejser sig, men en betydelig Del fastholdes af Vegetationen, raadner hen til et blaalighvidt Skum og bundfældes senere som et sort, stinkende Dynd henover Bunden. I de Tilfælde, hvor Kysten bestaar af Sand eller Kalk, kan man længe se Dyndet blive staaende i store, sorte begrænsede Flager, der skvulper frem og tilbage over den underliggende hvidgule Bund. Derimod har jeg aldrig truffet tilsvarende Kystaflejringer af Planktondiatomeer, der ganske mangler Evnen til at danne Vandblomst, et Fænomen, der staar i Sammenhæng med Tilstedeværelsen af Luftvacuoler. Ogsaa Aflejringer af dyriske Planktonrester langs Søbredderne er i alt Fald sjældne; i de enkelte Tilfælde (28), hvor jeg har truffet dem, har de bestaaet af Krustaceehude.

Gennem Søens Afløb vil fremdeles betydelige Mængder af Plankton kunne føres ud af Søen, og i de fleste Tilfælde vil der gennem Afløbet udføres langt mere end der med Tilløbene tilføres. Gudenaaen løber f. Eks. praktisk set planktonfri ind i Silkeborgsøerne og forlader disse ladet med uhyre Planktonmængder. Af Strømmens Styrke, Søens Dybde og Form vil det afhænge, hvor meget Plankton der føres ud. Ved Net, som har staaet i Afløbene, dels fra Furesøen, dels fra Silkeborgsøerne, har jeg overtydet mig om, at det hovedsagelig er Phytoplankton, der føres ud, Zooplankton derimod i langt ringere Grad; enkelte af dettes Komponenter, navnlig visse hyppig dybtstaaende Krebsdyr *(Leptodora hyalina)* træffes aldrig i Afløbet, om der end samtidig ude i Søen kan træffes uhyre Sværme[1]). Aarsagen hertil ses let, thi da Strømstyrken aftager udad og nedad mod Søbunden, er det navnlig det i de højere Vandlag staaende Phytoplankton, der føres ud, medens dette i mindre Grad er Tilfældet med det dybere staaende Zooplankton.

Man vil heraf forstaa, at Hovedmassen af Zooplankton vil blive aflejret som Søgytje, medens i alt Fald en ikke ubetydelig Del af Phytoplanktonet enten vil føres ud eller aflejres paa Kysten. Det Mængdeforhold, der eksisterer mellem en Søs Phyto- og Zooplankton, vil for de tilsvarende Skeletdeles Vedkommende altsaa ikke genfindes i Gytjen ude paa Dybet.

2. Under den Fordøjelsesproces, som man med v. POST maa antage, at alle Bundfældninger undergaar ved den i Søbunden levende Fauna, forholder de forskelligartede Skeletdele sig ingenlunde ens. Saaledes maa man formode, at Cellulosen af de ovennævnte Skeletdele lettest spaltes og omsættes, Kitinhudene derimod kun for en Del, og at Diatomeeskallerne næsten gaar uskadte gennem Tarmkanalen. Allerede v. POST og senere hen BORGE (5) har vist, at Diatomeerne og Desmidiaceerne altid var takkede i Kanten, som om de var bidte eller havde været udsatte for en eller anden Opløsningsproces. Noget lignende har jeg vel set, men skønner dog ikke, at Fænomenet har den Almengyldighed, som i Almindelighed tilskrives det. Undersøger man Tarmkanalens Indhold hos *Chironumus*-Larver fra c. 40 M., vil man foruden en stor Mængde ubestemmelige Stoffer finde uskadte Diatomeer samt større mørkere Stykker, der sikkert hyppigt er Kitin. Sætter man Larverne i rent Vand og lader dem udtømme Tarmen, vil man ved Undersøgelsen af de smaa grynede, aflange Ekskrementer kun kunne paavise ringe Spor af Kitinhudene; det er næppe rimeligt, at de direkte fordøjes af Dyrene, men de sønderdeles, er mere bløde og bøjelige, og naar Processen er

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[1]) Det maa bemærkes, at Nettene altid kun har staaet om Dagen; om Natten vilde Forholdene muligvis have været lidt anderledes.

endt, efter al Sandsynlighed mere udsatte for Hensmuldring og Opløsning. — Ogsaa heraf vil man forstaa, at Forholdet mellem de enkelte Komponenters Skeletdele i Søgytjen forrykkes og stiller sig forskelligt fra, hvad man alene efter Kendskabet til Søens Plankton kunde vente.

3. Gennemstrømmes en Sø af en Flod, som forinden har optaget Tilløb fra andre Vandbassiner, vil Floden medføre disse Bassiners Plankton og aflejre en Del af samme i vedkommende Søs Gytje. Denne bliver i saa Fald ikke Udtrykket for Søens Plankton, men der opstaar ogsaa i dette Tilfælde en Blandingsgytje, som vil forekomme Iagttageren ganske uforstaaelig, saafremt han ikke kender de lokale Forhold. Slige Blandingsgytjer forekommer her i Landet i flere af Gudenaaens Søer.

4. Hvad der dog mulig mest af alt bidrager til at skabe Uensartethed mellem Plankton og Søgytje, er, at de forskellige Skeletdele bortset fra Bundfaunaens Indflydelse ikke konserveres lige længe i denne. Vort ringe Kendskab til flere af de omhandlede Skeletdeles kemiske Sammensætning og de Omdannelsesprocesser, de undergaar i Søgytjen, bevirker imidlertid, at der ikke kan gøres Rede for alle de herhenhørende Forhold. Det synes, som om Cellulose-Skeletterne først af alle opløses og forsvinder. Selv i Søer (f. Eks. Sorøsø), hvor *Ceratium hirudinella* i August—September opnaar kolossale Maksima, har jeg i Maj ikke kunnet paavise et eneste Skelet af denne Flagellat i Søgytjen; derimod er Skeletterne af flere *Peridinium*-Arter ikke ganske sjældne i forskellige Søgytjer, hvilket er saa meget mærkeligere, som disse ikke optræder i saa store Mængder som *C. hirudinella.* Alt tyder dog paa, at Peridineernes Cellulose tidlig forsvinder af Søbunden og muligvis undergaar den samme Gæringsproces som anden Cellulose, ved hvilken denne spaltes i Sumpgas CH_4 og Kulsyre CO_2. (Wolney [29] pag. 9.)

Bundundersøgelserne har vist, at Pediastraceernes og Desmidiaceernes Cellevæge i meget lang Tid konserveres i Søgytjen, samt at de i de fleste af vore Søgytjer endog er mere almindelige end i de paagældende Søers Plankton. I fuld Overensstemmelse hermed har Borge (6) beskrevet en hel Række Desmidiaceer og *Pediastrum*-Arter, deriblandt adskillige Planktonarter fra gamle gotlandske Ferskvandsgytjer. Saafremt disse Formers Cellevægge virkelig skulde vise sig at bestaa af Cellulose, synes denne i alt Fald at være mere modstandsdygtig overfor ydre Paavirkninger end Tilfældet ellers er.

Af alle Plantestoffer lader Kutinen sig formentlig længst opbevare uforandret, og det er navnlig paa Grund af dette Stofs Uforgængelighed, at vi kan danne os et saa fyldigt Billede af vort Lands Fortidsflora. At Cyanophyceernes Cellevægge i alt Fald ikke bestaar af Kutin, der ganske svarer til de højere Planters, fremgaar alene deraf, at disse Planters Cellevægge næsten aldrig lader sig paavise i Søgytjen; de synes at forholde sig paa en ganske lignende Maade som Cellevæggene hos Peridineerne. Meget ofte kendetegnes Søer med høje Cyanophyceemaksima i August—September Maaned allerede paa Afstand ved Vandets hæslige Lugt, der ofte kan være saa ulidelig, at man paa stille Sommerdage knapt kan holde ud at ro paa dem. Stanken, der klæber ved Dyndet i saadanne Søer, er dog af en endnu mere ondartet Natur og bærer tydelige Vidnesbyrd om de Omsætninger af organisk Stof, der her foregaar. Dyndets Farve er blaasort, undertiden med et grønligt Skær, meget fintdelt og blødt at føle paa; tørret antager det en blaalighvid, ofte grønlig Tone. Undersøgt under Mikroskopet viser det i sin reneste Form kun faa bestemmelige Dyre- og Plantelevninger, og uden andet Kendskab til dets Bestanddele vilde man ved simpel mikroskopisk Iagttagelse vanskelig kunne paavise dets Oprindelse; dog indeholder det altid som alle andre Søgytjer Diatomeer, ganske særlig *Melosira* og *Stephanodiscus Niagaræ.* Det maa blive en speciel kemisk Analyses Sag nærmere at undersøge den Gæringsproces, hvorved rimeligvis særlig om Efteraaret de blaagrønne Algers Cellevægge og Celleindhold spaltes og omsættes.

Betydelig mere holdbare i Gytjen synes derimod alle Kitinlevningerne at være; dog viser det sig, at ogsaa Kitinskeletterne, saafremt de ikke er af en vis Tykkelse og ikke bestaar af større sammenhængende Flager, opløses og tilsyneladende forsvinder. Saaledes mangler med Undtagelse af enkelte særlig tykhudede Rotiferer *(Anuræa, Brachionus)* alle Hjuldyrskeletter i Søgytjen. Faktisk opløser disse særlig tynde Kitinskeletter sig, inden de bundfældes. Saaledes har jeg med Planktonnettet faaet store Mængder af dødt Plankton bestaaende af halvt opløste Kitinhude af *Notholca longispina* og *Asplanchna* op fra dybt Vand, i Furesø paa 30 M., i Madumsø paa 10 M. Ikke alene var alle bløde Dele borte, men af *Notholca longispina* var hyppig kun de lange Torne og af Asplanchnerne kun smaa uregelmæssige Kitinlapper tilbage. Ganske lignende Iagttagelser har jeg kunnet anstille paa *Dinobryum*-Skeletterne.

Foruden de smaa afrundede Hylstre af *Codonella lacustris,* som er almindelige i alle Søgytjer og typiske for Esromsøs, er det fortrinsvis Krustaceernes Kitinhude, der aflejres og øjensynlig i lange Tider forholder sig uforandrede. Mindst gælder dette om Kopepodernes Hudskeletter; formodentlig løsnes her de enkelte Ringe fra hinanden, hvorved Skelettets Henfald selvfølgelig fremskyndes i høj Grad. I August Maaned undersøgte jeg i Furesøen det døde Kopepodplankton, men de enkelte Hude var her helt sammenhængende, og Adskillelsen i enkelte Ringe maa altsaa formodentlig foregaa paa et senere bundfældet Stadium.

Hos Daphnierne, hvor Kitinen danner store uleddede Flader bestaaende af det store Hovedskjold, de endnu større Valver og den meget tykhudede Hale, bundfældes disse Stykker hele og med deres ydre Form og Struktur vel bevaret. Ganske særlig gælder dette, hvad der ogsaa er TRYBOM (22) o. a. vel bekendt, for Bosminernes Vedkommende, hvis Valver og Hovedskjold med de mægtige Antenner hører til de i Søgytjen hyppigst forekommende Kitinlevninger.

Af alle de i Søgytjen bundfældede Skeletdele synes dog ingen i Retning af Holdbarhed at kunne maale sig med de af Kiselsyre dannede Skeletter. Herved bliver Diatomeeskallerne, hvad ogsaa Undersøgelsen af gamle Søgytjer tilfulde godtgør, de Skeletdele, der længst af alle konserveres i Gytjen; Diatomeerne bliver følgelig en af de allervigtigste og i alt Fald en af de mest iøjnefaldende Komponenter i Søgytjen. Det maa blive en Specialundersøgelses Sag at udrede de talrige Spørgsmaal, som opstaar ved Studiet af Søgytjernes store Diatomeeaflejringer; Undersøgelser paa disse Omraader vil kunne faa baade videnskabelig og praktisk Betydning; jeg skal her indskrænke mig til at rede Spørgsmaalene ud fra hverandre og fremsætte enkelte Betragtninger, som denne mere almindelige Undersøgelse af Søbunden har fremkaldt.

Vore Søgytjers Diatomeeaflejringer stammer dels fra Plankton, dels fra Bredderne, hvis Plantevækst og Sten som bekendt hyppig er dækkede med de mørkebrune, geleagtige Skorpeovertræk, der væsentlig bestaar af Diatomeer; endelig huser muligvis selv vore dybeste Søbunde en egen, her levende Flora af Diatomeer. Vore dybeste Søgytjers Diatomeeaflejringer, saaledes som de kendes fra Haldsø og Furesø (c. 40 M.), bestaar aldeles overvejende af Planktondiatomeer, som oftest kun af ganske enkelte Arter, der da til Gengæld ofte er til Stede i enormt Individantal (Haldsø); de samme Arter, der udgør Hovedformerne i Planktonet, danner i Almindelighed ogsaa Hovedformerne i Søgytjerne. Haldsøs Plankton og Søgytje karakteriseres saaledes ved enorme Skalmængder af *Stephanodiscus Niagaræ,* Furesøens ved Slægten *Fragilaria* og ved *Cymatopleura elliptica.* Slægten *Melosira,* der rimeligvis optræder med det største Individantal i vore forskellige Søer, er ogsaa den Slægt, der særlig dominerer i Søgytjerne; disse saavel som *Stephanodiscus* mangler, saa vidt det er mig bekendt, aldrig i vore Søgytjer, af hvad Beskaffenhed disse iøvrigt end er. Desforuden finder man et noget forskelligt Antal Skaller af Bund- og Bredformer, som dog, hvad Individantal angaar, staar uendelig langt tilbage for Planktondiatomeernes; derimod overgaar de dem rimeligvis betydelig i Artsantal. For Haldsøs og Furesøs Vedkommende har jeg med Sikkerhed kunnet paavise, at Bundformerne tiltager i Antal ind imod Land; i Prøver fra 10 og 15 Meter er de betydelig hyppigere end i Prøver fra ca. 40 M. Hvad der bidrager til at øge Bund- og Breddiatomeernes Antal i Søgytjer, endog i betydelig Afstand fra Land, er den ofte rige Diatomeebelægning paa Vandplanterne, særlig saadanne, som ude paa c. 5 Meter Vand endnu sender deres Skud op til Overfladen. Naar disse Planter (f. Ex. *Potamogeton lucens*) om Efteraaret raadner bort, gaar lange Stykker til Søs med Bølgerne og bundfældes sammen med Diatomeerne længere ude. Det synes iøvrigt, som om Vandplanterne i de Søer, hvor Kalkudskillelsen er særlig stærk (Furesø), sjældent har saa stærke Diatomeebelægninger som i de Søer, hvor Kalkbelægningerne kun er ringe (Tjustrupsø).

Hvor vidt der i de dybeste Søgytjer findes levende Bunddiatomeer indgaaende som varigt Led i disses Flora, vides ikke, da Diatomeefloraens bathymetriske Udbredning er os -ukendt; jeg betragter det iøvrigt som usandsynligt. Den Mulighed er nemlig ikke udelukket, at de levende Individer af Bunddiatomeer, som aldrig ganske mangler selv i vore dybeste Søgytjer, og som udmærker sig ved normalt farvede Kromatoforer, er løsrevne Bredformer, der herude kun fører en kort, hensygnende Tilværelse. Indtil nærmere Undersøgelser foreligger, bør man vistnok holde sig til denne Anskuelse, fordi den er i Overensstemmelse med de Resultater, Kirchner (19) pag. 39) er kommen til for Bodensøens Vedkommende, og som Forel (10) for nylig har udtalt i sin »Handbuch der Seenkunde 1901«. Han siger her (pag. 188), at de dybe Søbundes Diatomeeflora »entstammt der littorale Region und sind von dort zufällig verschleppt worden« og formoder endog, at disse Diatomeer om Sommeren, naar Vandet er relativt uigennemsigtigt, fuldstændig forsvinder. Kromatoforernes brune Farve er intet afgørende Bevis for, at Diatomeerne er hjemmehørende i de dybe Søgytjer; Kromatoforernes Holdbarhed er nemlig særdeles stor. Selv har jeg haft Diatomeer liggende i afproppet, halvtørt, men iøvrigt ikke konserveret Dynd i ca. 3 Maaneder, uden at deres brune Farve gik tabt, og Kirchner (19) angiver pag. 31. at han har holdt forskellige Diatomeer i absolut Mørke i $3^1/_2$ Maaned, uden at de døde eller viste nogen Affarvning af Kromatoforerne.

De forskellige Diatomee-Arter konserveres paa forskellig Vis og ikke alle lige godt i Søgytjen. Det er saaledes ikke lykkedes mig at finde Skallerne af *Atheya* og *Rhizosolenia* selv i de Søers Gytjer, hvor i alt Fald den sidstnævnte Form om Efteraaret var overordentlig almindelig. Andre Former med meget tynde Skaller, f. Eks. *Synedra acus var. delicatissima*, optræder derimod ret hyppigt. Skeletter af Diatomeer, som ikke danner Kæder eller Stjærner (f. Ex. *Cymatopleura elliptica, Stephanodiscus Niagaræ*), aflejres under ganske den samme Form, som da de omsluttede den levende Planktonorganisme. Derimod skiller Enkeltindividerne i de stjærne- og baanddannende Diatomeer sig i Almindelighed fra hverandre. Saaledes aflejres *Asterionella gracillima* ikke som Stjærne, men som Enkeltindivid; det samme er Tilfældet med *Tabellaria fenestrata*, hvor dog to—tre Individer som oftest findes sammenhængende. Af Fragillarierne bevares hos *F. virescens* ofte Kæder paa c. 20 Individer, hvorimod man af *F. crotonensis* sjældnere ser et saa stort Antal Individer sammen. *Melosira arenaria* er næsten altid opløst i Enkeltindivider; de øvrige Melosirer bevares i Almindelighed i temmelig lange Kæder.

Af de her meddelte Iagttagelser vil man forstaa, at der ikke kan være nogen absolut Overensstemmelse mellem Planktonets Diatomeer og Gytjens Diatomeeaflejringer; enkelte meget hyppige Planktondiatomeer, særlig *Asterionella gracillima*, spiller saaledes ikke fuldt saa stor en Rolle i Søgytjen, som man skulde formode.

Kendskabet til Længden af den Tid, hvori Planktonorganismernes Skeletdele holder sig, er i høj Grad betydningsfuldt for Studiet af Planktonets Indflydelse paa de forskellige Gytjearter. Tænker man sig nemlig en omtrent samtidig Bundfældning af *Ceratium hirudinella* og visse Planktondiatomeer, vil førstnævnte efter kun et Aars Forløb, eller maaske før, være forsvundet af Gytjen, hvorimod Diatomeeskallerne muligvis vil kunne holde sig i ubestemmelig Tid. Idet der nu aarlig finder en Bundfældning Sted baade af *C. hirudinella* og Diatomeer, og idet førstnævntes Skeletdele hurtigt forsvinder, hvorimod Diatomeernes ophobes, bliver det indlysende, at man ved Studiet af vedkommende Søgytje nærmest maatte komme til den Slutning, at Planktonbundfældningerne paa vedkommende Lokalitet kun havde bestaaet af Diatomeer.

Skønt der saaledes findes en hel Række Forhold, der fremkalder Uensartethed mellem Søens Gytje og dens Plankton, har dog de ovenfor opstillede tre Hovedtyper for Søgytjer: Diatomeegytje, Cyanophyceegytje og Kitingytje formentlig nogen større Betydning end den at være Udgangspunkter for en mere indgaaende Fremstilling af disse. Ofte støder man, hvad Tavle 3 tydelig godtgør, nemlig paa Søgytjer, som træffende karakteriseres ved Navnet Diatomeegytje, endnu hyppigere paa Cyanophyceegytjer, hvor den ilde Lugt og blaasorte Farve, der ved Tørring af Gytjen bliver graagrøn, giver sikker Vejledning, selv i Tilfælde, hvor et stort Diatomee-Indhold vilde vække Betænkelighed for Anvendelse af Navnet Cyanophyceegytje.

Grunden til, at vi i alt Fald her i Landet har typiske Diatomeegytjer, saavel som typiske Cyanophyceegytjer, er den, at vore Søer saa godt som aldrig yder lige gode Livsbetingelser for Diatomeer og Cyanophyceer; selv hvor Plankton rummer Repræsentanter for begge disse Plantegrupper, opnaar i Almindelighed kun den ene af dem de kolossale Maksima, der faar den afgørende Indflydelse paa Søgytjens Sammensætning. De høje Diatomeemaksima naas i de dybe, kolde og klare Søer, hvor Bundtemperaturen, selv i den varmeste Sommertid, ikke stiger synderlig over 7—8° C., hvorimod Cyanophyceerne naar deres stærkeste Udvikling i lave, varme Søer, hvor Bundens Temperatur allerede i Juni Maaned er omkring 10° C. Da vi her i Landet kun har faa dybe, kolde Søer, er ogsaa de typiske Diatomeegytjer forholdsvis sjældne (Tjustrupsø Bundtemperatur 1. Aug. 1900 + 9° C., Haldsø Bd.tp. 23. Juli 1900 + $6^1/_2$° C.), hvorimod Cyanophyceegytjer paa Grund af Landets Rigdom paa lave, varme Søer er meget almindelig (Viborgsøerne Bd.tp. 27. Juli 1900 + 12° C., Gudensø 20. Juli 1900 + 14° C., Julsø 19. Juli 1900 + 12° C.)

Ikke saa hyppigt støder man i Søerne paa Gytjer, der med Rette kan benævnes Kitingytjer. Grunden hertil er den, at vi kun har faa (som oftest mindre Søer, Madumsø, Gribsø, Bagsværdsø), hvis Plankton særlig bestaar af kitinproducerende Organismer; disse danner derimod større eller mindre Maksima saavel i Søer med høje Diatomee- som med høje Cyanophycee-Maksima. Det synes, som om de mere udprægede Kitingytjer fremkommer i de Tilfælde, hvor Søbunden indeholder store Mængder af uorganisk Materiale, navnlig Ler. Hverken Diatomee- eller Cyanophyceegytjen kan, saa længe de indeholder ringe Mængder af uorganiske Stoffer, opbevare de betydelige Mængder af Kitinhude, som man alene efter Kendskabet til de høje Maksima, Kopepoder og Daphnier opnaar i vedkommende Sø, skulde formode. Kitinhudene konserveres øjensynlig længere i stærkt lerholdige Gytjer end i saadanne, der væsentlig opbygges af Materiale af organisk Oprindelse.

Endnu skal vi om Diatomeegytjen tilføje følgende:

Diatomeegytjen er, naar den direkte tages op fra Søbunden i sin reneste Form sort af Farve; Prøver fra Haldsø antog efter 3 Maaneders Henstand i Formol lidt efter lidt en lys, graalig Farve; tørrede var Prøverne endnu lysere, og behandlede med Syrer præsenterede de sig kridhvide. Den sorte Farve skyldtes Kromatoforerne, som efter Døden bliver blaaviolette eller sorte. Haldsøs Gytje indeholdt næsten intet uden Diatomeeskaller aflejrede i en kulsort Masse, der under Mikroskopet opløste sig i et fint Pulver, som formentlig væsentlig bestod af Kromatoforer; disse træder rimeligvis ud, naar de to Skaller enten brydes i Stykker eller gaar fra hinanden; muligvis har en meget stærk Bundfældning af *Ceratium hirudinella*, hvis Kromatoforer antager samme Farve, bidraget til yderligere at give Gytjen sit ensartede, sorte Præg.

Medens ældre diatomeeførende Ferskvandslag er velkendte saavel her i Landet (Hartz og Østrup) som i Nord-Tyskland o. a. Steder, har man, saavidt jeg ved, kun to Gange tidligere fundet Diatomee-Aflejringer, hvis Dannelse endnu foregaar den Dag i Dag. Begge disse Aflejringer, henholdsvis i en Sø ved Stavanger (Reusch [16]) og Søen Nömmen i Jönköping Len (Tryblom [26] pag. 11), foregaar inde paa faa Meter Vand, er af ringe Udstrækning, synes ikke at skylde Planktondiatomeer deres Oprindelse og lader sig derfor ikke sammenligne med Aflejringerne i Haldsø.

At disse Aflejringer, der saa vidt vides strækker sig over hele Søbunden og som indeholder utrolige Mængder af Diatomeeskaller, næsten udelukkende opstaar ved Bundfældning af Planktondiatomeer, derom er der ingen Tvivl. Ogsaa de øvrige, mindre rene Diatomee-Aflejringer i Tjustrupsø, Mossø og Furesø bestaar næsten udelukkende af Planktondiatomeer. Jeg maa saa meget des stærkere fremhæve dette, som de i Genfersøens og Bodensøens Bund fundne Diatomeeskaller ganske hovedsagelig angives at være Bund- og Bredformers; de publicerede Lister indeholder kun faa Planktondiatomeer. Endvidere angiver Kirchner (19) pag. 39, at der i Bundprøven fra 240 og 160 M. i Bodensøen kun fandtes tomme Skaller »in sehr geringer Menge«; for Genfersøens Vedkommende nævner endog Forel (9) pag. 141 i sit Kapitel *Débris organiques divers* aldeles ikke Diatomeeskallerne mellem Aflejringerne i la région profonde; Bredformerne, der spiller saa stor en Rolle ved Dannelsen af det senere omtalte »feutre organique«, standser ved 100 M. Af Schröter og Kirschners Undersøgelser ved vi, at der i Bodensøen findes et rigt Diatomeeplankton; af Blancs (4) Arbejde fremgaar, at dette ogsaa er Tilfældet i Genfersøen, men nærmere Oplysninger om denne Søs Phytoplankton foreligger endnu ikke. Hvad bliver der af Skallerne fra disse Søers Diatomeeplankton, og hvad er Aarsagen til, at Planktondiatomeerne i vore Søer opdynges i utrolige Mængder paa Søbunden, medens tilsvarende Mængder ikke lader sig paavise paa Schweizersøernes Bund? Er der en Mulighed for, at Diatomeskallerne i meget dybe Søer (2—300 M.) opløses, og at Konserveringen kun finder Sted i forholdsvis lave Søer? Foregaar der endvidere efter Bundfældningen ogsaa i vore Søer en Opløsning, saaledes at Diatomeeskeletterne forsvinder af Søgytjen, eller bliver Diatomeegytjen, saaledes som vi nu kender den fra Haldsø, en Gang i Tiden til den typiske Diatomeejord? Besvarelsen af disse Spørgsmaal hører Fremtiden til; af deres Løsning afhænger den nærmere Forstaaelse af Diatomeejord-Aflejringerne og Betingelserne for disses Opkomst.

Det var særlig ved Studiet af de forskellige Silkeborg-Søer, at jeg blev klar over det nære Forhold, der i Reglen bestaar mellem Gytje og Plankton. Som bekendt begynder Silkeborgsøerne vestfra med Skanderborgsø, der gennem Taaningaa har Afløb til Mossø; i dennes vestlige Del løber Gudenaaen ind; dens Vandmasser influerer dog rimeligvis grumme lidt paa Mossøs, dels fordi Aaens Indløb og Udløb ligger ganske tæt ved hinanden, dels fordi den ubetydelige Del af Søen, som berøres af Aaen, ved en stor Tange er adskilt fra den egentlige store Sø. Efter at have forladt Mossø, optager Gudenaaen Saltenaa, der kommer fra Salten Langsø, hvorpaa den, efter at have dannet Gudensø, løber ind i Julsø; endnu danner den de tre mindre Søer, Borresø, Brassø og Silkeborg Langsø, hvorpaa den uden flere Bredninger løber ud i Randersfjord. Planktonundersøgelserne viste nu, at alle de Søer, der laa før Saltenaaens Indløb, havde høje Diatomeemaksima, de der laa efter dette derimod meget høje Cyanophyceemaksima. Disse Maksima skyldtes en enkelt Alge *Aphanizomenon flosaquæ*, som gennem Saltenaa i enorme Masser gødes ud i Gudenaaen, kort efter at denne, ladet med store Diatomeemængder, havde forladt Mossø. Paa det Sted, hvor Saltenaa flyder ud i Gudenaa, stod (16. Juli 1900) førstnævntes blaagrønne og sidstnævntes brune, diatomeerige Vand skarpt mod hinanden; længere nede slog Vandmasserne sammen og Planktonet blandedes; jo længere man kom mod Vest (bort fra Mossø), jo mere tog Diatomeerne af samtidig med, at Vandblomstfænomenet blev stærkere og Chyanophycee-Maksima'erne højere. Ved endvidere at undersøge Gytjerne saa jeg, at Skanderborgsøens Gytje væsentlig bestod af Diatomeer og Kitinhude og iøvrigt indeholdt betydelige Mængder af Kalk og Ler. Over Mossøs Grusbund laa det ovenfor omtalte graablaa Ler, rigt blandet med Diatomeer. I Søerne paa den anden Side af Saltenaa fandtes de blaasorte Cyanophyceegytjer, som iøvrigt indeholdt ikke ubetydelige Mængder af Diatomeer, der vel for en Del skyldtes de Individer, Gudenaaen havde ført med sig fra Mossø; lige saa skarp som Forskellen i alt Fald i hele Sommerhalvaaret var mellem Mossøs Diatomee- og Juelsøs Cyanophyceeplankton, var Forskellen mellem førstnævntes graa diatomeeholdige Ler og sidstnævntes blaasorte Cyanophyceegytje.

Foruden de tre ovennævnte Typer paa Søgytjer og de ved Blanding af disses Bestanddele opstaaede Blandingsgytjer bevirker endvidere rigelig Tilførsel af uorganisk Materiale, hos os altsaa særlig Ler og Kalk, at yderligere Blandinger opstaar. Af saadanne maa særlig tre: Cyanophyceeleret, Diatomeeleret og Diatomeekalken nævnes.

Ved Cyanophyceeleret forstaar jeg saadanne stærkt lerholdige Søgytjer, der opstaar i Søer med høje Cyanophyceemaksima og rige Bundfældninger af disses Cellevægge; de er særlig fremtrædende i visse Silkeborgsøer, f. Ex. i Borresø ud for de saakaldte Paradisøer. Som Diatomeeler betegner jeg Mossøs yderst kalkfattige Lerlag og formoder, at denne Betegnelse ogsaa maatte kunne anvendes for større Partier af Bundarter fra Furesøens dybeste Partier. Diatomeekalken er den eneste naturlige Betegnelse for Tjustrupsøs meget kalkholdige og yderst diatomeerige Søgytje: de to Benævnelser Diatomeeler og Diatomeekalk har allerede tidligere fundet Anvendelse. Til Betegnelse af de forskellige Bundarter i vore dybere og større Søer foreslaar jeg altsaa nu følgende Terminologi:

1. Overvejende organisk Materiale . . .	Cyanophyceegytje. Diatomeegytje. Kitingytje.
2. Blanding af organisk og uorganisk Materiale	Cyanophyceeler. Diatomeekalk. Diatomeeler.
3. Overvejende uorganisk Materiale . .	Indsøler. Søblege.

Kunde man tilvejebringe tilstrækkelig dybtgaaende Bundprøver, vilde det formodentlig vise sig, at den Rækkefølge, hvori disse Dannelser er nævnede, tillige vilde genfindes i Bundprøverne. Vi vilde f. Ex. saaledes vente at kunne finde:

Cyanophyceegytje.	Diatomeegytje.	Diatomeegytje.
Cyanophyceeler.	Diatomeeler.	Diatomeekalk.
Koprogent Indsøler.	Koprogent Indsøler.	Koprogen Søblege.

Det staar endnu kun tilbage at omtale Faunaen paa vore dybere Søers Bund og gaa lidt nærmere ind paa den Indflydelse, denne Fauna øver paa de forskelligartede Bundfældninger.

Søbundens Fauna bærer udenfor c. 11 Meter overalt Præget af en ikke ringe Ensformighed; gennemgaaende træffes de samme Slægter med de samme Arter i hver eneste Sø; mellem Faunaerne i vore forskellige dybere Søers Bund synes der kun at være den Forskel, at de enkelte Komponenter ikke optræder lige talrigt i dem alle.

Mellem Insekterne bør særlig Myggelarverne, henhørende til Slægterne *Chironomus* og *Tanypus*, fremhæves. Navnlig førstnævntes, ofte tommelange Larver, træffes overordentlig hyppigt endnu paa 40 Meter Vand. *Sialis*-Larverne er i Haldsø endnu paa 20 M. meget almindelige og er af alle Insektlarver, naar Myggelarverne undtages, de, der gaar længst ud. Ud over *Atax crassipes*, der næppe fattes som Planktonorganisme over nogen af vore dybere Søbunde, har jeg fra større Dybder ikke faaet andre Hydrachnider op. Af Krebsdyrene opnaar Gammariderne, repræsenterede ved 2—3 Arter, sjældent noget stort Individantal, men findes endnu paa 40 Meter. Daphnierne gaar saa vidt mig bekendt ikke ud over 12 M., men nøjere Undersøgelser vil mulig give et andet Resultat. Derimod findes Ostracoderne repræsenterede i vore dybeste Søgytjer med c. 4—5 Arter og ofte i meget stort Individantal; dette er særlig Tilfældet i Furesøen, hvorfra tillige et Par Bundcopepoder kendes. Hvad Molluskerne angaar, standser som ovenfor fremhævet alle Snegle ved c. 8 Meter, hvorimod *Anodonta* og *Unio* gaa ud til c. 11 Meter; kun Pisidierne naar ud til Søernes dybeste Partier, men træffes dog sjældent i større Mængde. Ingen af Iglerne tilhører vor Dybsøfauna, hvorimod de dybeste Søgytjer huser en artfattig, men undertiden overmaade individrig Oligochætfauna. Om Turbellarierne kan foreløbig ingen Oplysninger gives, da denne Dyregruppe endnu er for lidet eftersøgt. Hvad vi kender af Spongiller og Bryozoer ud over 11 Meter er kun ubetydeligt; de findes ret ofte paa Muslingskaller. Rotifererne hører ikke hjemme paa dybere Vand, og Hydra har jeg hidtil ikke truffet udenfor Vegetationszonen. Infusionsdyrene fra dybere Søgytje er endnu ikke studerede; Udbyttet vil næppe blive stort. Anderledes stiller det sig med Rhizopoderne, hvoraf de dybere Partier af Søerne huser en Del.

Grunden til, at jeg ikke her gaar nærmere i Detail med Hensyn til de enkelte Komponenter i de dybere Bundgytjers Fauna, er særlig den, at der fra andre Sider er monografiske Bearbejdelser under Udarbejdelse over vore ferske Vandes Copepoder, Ostracoder og Oligochæter; egne Undersøgelser over Rhizopodfaunaen paa dybere Vand er endnu kun paabegyndt. Inden disse Undersøgelser, som til Dels er foretagne Haand i Haand med de her publicerede, er afsluttede, kan nøjere Angivelser hverken i faunistisk eller i biologisk Henseende meddeles.

Bundfaunaens Betydning ved Spørgsmaalet om Gytjedannelsen er af dobbelt Natur; dels er Faunaen selv bundhøjnende og bidrager til Dannelsen af de Elementærbestanddele, hvoraf Gytjen opstaar, dels er dens Virksomhed af en fordøjende Natur, ved hvilken Elementærbestanddelene omdannes til Ekskrement; først ved denne Proces er det, at den Jordart, vi betegner Gytje, fremkommer.

Undersøgelsen af Bundfaunaens Betydning som bundhøjnende frembyder ikke særlig store Vanskeligheder. Man kan i enhver Søgytje altid paavise en stor Mængde fra Bundfaunaen hidrørende Skeletdele, og paa mange Lokaliteter spiller disse endog en meget stor Rolle. Hovedmassen bestaar af Kitin, men Skallerne af Pisidium og Ostracodskallernes høje Kalkprocent bidrager antagelig, i alt Fald paa mange Steder, noget til at forøge Bundens Kalkmængde. Mellem de vigtigste Kitinlevninger bør de stærkt kitiniserede Hoveder af Myggelarver, de enkelte Ringe af Sialislarven og af Bundens Amfipoder nævnes; desforuden Æggekapsler frembragte af Bundens Oligochætfauna; i de fleste Søer spiller tillige Rhizopod-Hylstrene en ikke ringe Rolle; om andre Kisel- og Kitinlevninger se 28; særlig fremtrædende i Søgytjerne er *Bithynia*laagene.

Undersøgelsen af Bundfaunaen som fordøjende Faktor og Fordøjelsesprocessens forskelligartede Indflydelse paa Bundens enkelte Elementærbestanddele frembyder langt større og for Øjeblikket ret uovervindelige Vanskeligheder; der foreligger ingensomhelst Undersøgelser over disse vidtstrakte og for det mere indgaaende Studium af Søgytjen meget vigtige Omraade. Jeg maa derfor foreløbig indskrænke mig til et Par enkelte Bemærkninger af mere teoretisk Natur.

Ud fra de Resultater, som er indvundet ved Planktonundersøgelserne, maatte man egentlig vente, at der lod sig spore en Lagdeling i vore Søbunds-Aflejringer. Planktonundersøgelserne har nemlig vist, at de forskellige Organismers Maksima indtræffer i lovbunden Rækkefølge, altsaa Aar efter Aar til noget nær det samme Tidspunkt. Da Diatomeerne i al Korthed lader sig betegne som Koldtvandsplanter, der naar deres højeste Maksima i Begyndelsen og Slutningen af Vinterhalvaaret, sker Bundfældningerne af Kiselskeletterne i Søer med høje Diatomeemaksima særlig i Maj og i November Maaned; om Sommeren, naar Diatomeernes Antal er mindre og navnlig *Ceratium hirudinella*, *Dinobryum* og *Crustaceerne* dominerer, foregaar der Bundfældninger af anden kemisk Natur. Da Cyanophyceerne omvendt er Varmtvandsplanter, har disse hyppigst deres højeste Maksima i Sommertiden. hvorfor de stærkeste Kutinbundfældninger sker om Efteraaret; om Vinteren og i Foraarstiden vil der i Søer med høje Cyanophyceemaksima især finde Bundfældninger Sted af Rester fra *Daphnia* og Hjuldyrsværmere.

Idet der saaledes til forskellige Tider af Aaret bundfældes ganske forskelligartet Materiale, maatte man formode, ikke alene, at der paa Søbunden lod sig spore en Lagdeling, men ogsaa, at der maatte vise sig stor Forskel i disse enkelte Lags kemiske Beskaffenhed. Noget saadant lader sig dog hverken paavise i Nutidens eller i Fortidens forlængst tørlagte Søgytjer; Bundfaunaen bevirker ved sin Omdannelse af Materialet til Gytje en Gennemrodning og Omlejring af Bunden, hvorved enhver oprindelig Lagdeling maa gaa tabt.

Resultatet af Bundfaunaens og Bakteriernes samlede Virksomhed er som ovenfor omtalt den, at de organiske Stoffer mere og mere forsvinder, og at der til Slut væsentlig bliver et mineralsk Materiale tilbage. Skønt man til den nærmere Paavisning af de her henhørende Fænomener maa raade over flere Alen lange Jordpiller tagne i de paagældende Søbunde, giver dog alene de med Skraben foretagne Undersøgelser en Del ikke helt uvæsentlige Oplysninger.

Ved en nærmere Undersøgelse af det Mudder, som Skraben bringer op fra de dybere Søer, vil man næsten altid kunne paavise, at Mudderet i samme Bundprøve har forskellig Farve. Saaledes finder man, at der i Furesøens ensartede brungraa Mudder ligger mindre, samlede Partier af gult Mudder, som er langt mere fedtet at føle paa end det brungraa. Dette sidstnævnte kan i lang Tid henstaa uforandret og uden at udvikle ildelugtende Luftarter; det gule forandrer sig til et stinkende, fedtet, osteagtigt Lag, hvori øjensynlig gennemgribende organiske Omsætninger finder Sted. Blander man Indholdet af en Skrabe og lader en Prøve af Blandingen bundfælde sig i et Glas, dannes der nærmest Bunden et graablaat Lag, der senere overlejres af et Lag med en noget lysere, gullig Farve, hvilket med Tiden vokser i Tykkelse paa de andre Lags Bekostning. Allerøverst et brunt flotterende Lag, der ved den mindste Rystelse sættes i Bevægelse; dette Lag bestaar i alt væsentlig af Resterne fra Planktonsværmene, ganske særlig af Daphniernes Kitinhude o. s. v. Jeg formoder, at dette øverste Lag nogenlunde svarer til den over Søbunden staaende, endnu af Organismerne kun i ringe Grad rørte Fællesbundfældning, som derfor endnu ikke kan betegnes som Gytje; umiddelbart under dette findes rimeligvis det af Forel som *feutre organique* betegnede Lag, og hvori Hovedmassen af Bundens Organismer lever; derpaa følger det gullige Lag, der vel endnu kan gennemrodes af Myggelarver, Ostracoder, Orme etc., men som dog hovedsagelig danner Næringsbund for Bakterier; nederst staar det brungraa Lag, der er den mer eller mindre færdig bearbejdede, gennemekskrementerede Søgytje, svarende til den, som i tør Tilstand saa ofte beskrives fra Bunden af Fortidens ferske Vande. Omtrent samme Lagdeling mener Forel at kunne paavise i Genfersøen (8) (pag. 119).

Angaaende »le feutre organique« ogsaa kaldet »organicher Filz« henvises særlig til Forel (8) pag. 100. Dette Lag, der iøvrigt ogsaa findes i Smaasøer og lave Damme, gaar i Genfersøen ned til 80—100 M. Det bestaar af Palmellaceer, Croococcaceer og til visse Aarstider ganske særlig af Diatomeer. Oscillarierne væver Laget sammen til et filtet, sammenhængende Tæppe: Diatomeerne angives ogsaa her at være Bund- og Bredformer, som med Bølgerne er slæbt ud paa de store Dybder, hvor de en Tid lang vegeterer for dernæst, ifølge Forel, at gaa til Grunde og fuldstændig forsvinde; dette sidste menes særlig at finde Sted om Sommeren, naar Vandet er uklart, og Lyset ikke naar saa langt ned som om Vinteren.

Det er ikke lykkedes mig i vore Søer at paavise et ganske til Forels »feutre organique« svarende Lag. De optagne Bundprøver har overalt bestaaet af en saa henflydende, blød og løst sammenhængende Masse, at det har været mig umuligt at paavise en særlig Overflade for det Materiale, jeg fik op fra Bunden. En Bundfældning af Materialet i Glasskaale har heller ikke vist et saadant sammenhængende Overtræk af Alger etc., som Forel angiver. Jeg formoder, at »le feutre organique« svarer til Gytjens aller øverste Lag blandet med de nederste Partier af den i det foregaaende omtalte Fællesbundfældning.

Brand (7) (pag. 8) angiver, at der uden for *Nitella*-Zonen i Starnbergersee findes en særlig af Cladophoraceer dannet »Grundalgenzone« som fra c. 12 M. kan naa ned til c. 20 M. Denne Zone, der i vore Søer omtrent skulde findes der, hvor Skalbæltet hører op, er mig ukendt. Desværre har jeg først lært Brands Arbejde at kende, efter at Undersøgelserne ude i Naturen var afsluttet, og maa derfor lade det henstaa uafgjort, om en saadan Zone lader sig paavise i vore Søer. Fortsatte Undersøgelser og forbedrede Methoder maa forhaabentlig kunne bringe yderligere Oplysninger dels om disse øverste organiske Lag, dels om Forskellighederne i Søgytjens Farve ovenfra nedefter og om Aarsagerne hertil¹).

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¹) Efter at Trykningen af Arbejdet allerede var langt fremskreden, modtog jeg fra Hr. Fisker Chr. Lybek en Stikprøve af Bunden af Loldrupsø ved Viborg. Hr. Lybek, der havde været mig behjælpelig med Skrabningerne i Haldsø og paa anden Vis har bi-

Naar FOREL (10) (pag. 211) gaar ud fra, at alle organiske Partikler i den store almindelige Fællesbundfældning ved Organismernes Virksomhed omsættes og forsvinder af Søbunden, og at der som Følge heraf kun bliver en uorganisk, uopløselig Rest tilbage, som danner »die animalischen Seealuvionen (lehmigen Mergel)«, da er en saadan Generalisation muligvis tilladelig for de Aflejringer, der finder Sted paa de store Sødybder (300 M.), som FOREL har gjort til Genstand for sine Undersøgelser. I vore smaa lave Søer er en slig Generalisation næppe tilstedelig. Dels er Bundfældningen af organisk Materiale her saa overordentlig stor, at Processernes Enderesultat næppe altid bliver en uorganisk uopløselig Rest, dels er Mulighederne for en pludselig Afbrydelse af Omdannelsesprocesserne altid større, paa jo lavere Vand vedkommende Aflejring finder

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staaet mig med Undersøgelsen af denne Sø, meddelte mig i Sommer, at der fandtes Søkalkaflejringer i Loldrupsø; efter min Anmodning sendte han mig i Efteraaret Bundprøver herfra. Prøverne var næsten kridhvide, indeholdt 75.70 $^0/_0$ $CaCO_3$ og en ikke ringe Mængde Kiselsyre i Form af sammenkittede, vandklare Kvartskorn; organiske Stoffer syntes næsten ganske at mangle. Da jeg ikke selv kendte Søen, var det min Agt ikke at medtage disse Søkalkaflejringer i nærværende Arbejde, men bad foreløbig kun Hr. Lybek om muligt at skaffe mig Prøver fra Søbundens forskellige Lag; ved Tilsendelsen af den ovennævnte Stikprøve blev min Anmodning imødekommet og en Bundprøve af ikke ringe videnskabelig Interesse tilvejebragt.

Hr. Lybek ventede, indtil Søen blev tillagt, og konstruerede sig da selv et Apparat, der var i Stand til paa nogle Alen Vand at optage en lodret Jordpille paa $1^3/_4$ Alens Højde. Ved Optagelsen trykkedes Jordmassen sammen til $1^1/_4$ Alen samtidig med, at det øverste tyndtflydende Mudderlag løb af; Søens Dybde angives at være ringe; nærmere Oplysninger herom har jeg ikke kunnet tilvejebringe.

Den tilsendte Jordpille er $1^1/_4$ Alen lang, oventil er den næsten kulsort, i den nederste Ende derimod lysegraa; ovenfra nedefter gaar Farven fra sort jævnt over i graat. Pillens øverste Lag bruser næsten ikke for Syrer, det nederste derimod meget stærk; set under Mikroskopet iagttager man, at de øverste Lag indeholder langt større Mængder af organiske Stoffer end de nederste og tillige det ikke uvæsentlige Forhold, at Mængden af Diatomeeskaller her er langt betydeligere end i de nederste Lag.

Sted. Endvidere kan der paa Grund af den uhyre Mængde organisk Stof, der skal omsættes, og paa Grund af den Intensitet, hvormed Omdannelsen i vore forholdsvis varme Søer foregaar, under Processerne opstaa Biprodukter, der influerer paa de mineralske Bestanddele og virker opløsende paa disse; saaledes formoder jeg, at Kalkskeletterne i Silkeborgsøernes paa organiske Stoffer saa overordentlig rige Søgytjer opløses ved Syreudskillelse under disses organiske Omdannelsesprocesser.

Mulighederne for, at der i vore Søer som Følge af Organismens Virksomhed opstaar ret forskelligartede Aflejringer, er derfor ikke udelukket; i mange af vore Søer vil dog Forholdene (som angivet pag. 96) være i Overensstemmelse med Forels Opfattelse.

Ved at sammenligne den nederste Del af Pillen med den mig tidligere tilsendte Prøve af den hvide Søkalk er det øjensynligt, at Pillen ikke har naaet de Lag, hvorfra denne Prøve stammer. Hr. Lybek har nu tilbudt mig at modificere Apparatet saaledes, at Pillen kan føres en Alen længere ned.

Hvis en saadan Prøve kan tilvejebringes, vilde den efter min Opfattelse fortjene en nærmere, desværre ret kostbar Undersøgelse.

I forskellig Højde burde man vælge 4—5 Steder ud og underkaste disse Partier dels en fuldstændig kemisk Undersøgelse, dernæst en kvalitativ og kvantitativ bakteriologisk Undersøgelse, ligesom deres Diatomeemængde nærmere burde søges bestemt.

Man vilde ad denne Vej faa sikre Beviser for, at de organiske Stoffer aftager nedad, samtidig med at de uorganiske Stoffer tiltog, at Bakteriemængden aftager nedefter, og at Betegnelsen: koprogent Ler eller Kalk for Pillens nederste Lag er berettiget; endelig vilde den give Oplysninger om Diatomeeskallernes Opløsning i Pillens nederste Lag.

Fremtiden maa afgøre, om en saadan Undersøgelse kan komme i Stand; i hvert Fald skyldes der allerede foreløbig Hr. Fisker Chr. Lybek megen Tak for den Interesse, han har vist disse Undersøgelser.

Sammenfattende og afsluttende Bemærkninger.

1. Der er i dette Arbejde tilvejebragt Oplysninger om Aflejringer paa de danske Søbunde, for saa vidt de lader sig betegne som Søkalk, Bønnemalm eller Søgytje.

2. Ved Søkalk forstaas her alle de i vore større Søer optrædende Kalkaflejringer. Disse lader sig inddele i det lavere Vands og det dybere Vands Kalkaflejringer. Grænser mellem dem angives af Skalbæltet, i vore Søer beliggende mellem 8—9 og 11 Meter Kurven. Lavvandets Kalkaflejringer kan yderligere inddeles i to Grupper, de urene: Sømerglerne, og de mere ublandede: Characeekalk og Molluskkalk; Dybvandets i de to tilsvarende Grupper: Kalkgytje og Søblege.

3. Som Aarsager til Søbundens Kalkholdighed er der pag. 8 angivet forskellige, rimeligvis Haand i Haand virkende Faktorer; af disse tages der i dette Arbejde kun Hensyn til de i Søen levende kalkproducerende Organismer, som henføres til fire Grupper: Højere Vandplanter, Characeer, stenklædende, kalkinkrusterede blaagrønne Alger og Mollusker. Disse Gruppers Kalkinkrustationer, deres Oprindelse og deres Pulverisation er omtalt i Afsnittet om kalkproducerende Organismer; de af dem fremkaldte Aflejringer er, for saa vidt de har kunnet lade sig paavise, omtalt i Afsnittet om Kalkaflejringer.

4. For de højere Vandplanters Vedkommende er en Række Iagttagelser over Kalkinkrustationerne meddelte. Jeg har søgt at begrunde den fra tidligere Undersøgeres noget afvigende Opfattelse, at der fra disse Planter finder en stadig Neddrysning af Kalkpartikler Sted. Ved Analyse af Søbunden er det saa vidt mulig godtgjort, at dennes Kalkholdighed øges ved Vandplanternes kalkproducerende Virksomhed. Inkrustationerne hos disse Planter er, saa

vidt vides, kun Belægningsskorper, uafhængige af de underliggende Plantevæv.

5. Hos Characeerne er Kalkinkrustationerne, foruden at være Belægningsskorper, i Følge Kohl tillige knyttede til det underliggende Plantevæv og som Følge deraf delvis omgivne af organisk Materiale; fra de voksende Planter sker der en stadig Afbrækning af døde Dele, der aflejrer sig umiddelbart om Planten.

6. Kalkskorperne paa vore Søers Strandsten er af forskellig Oprindelse; herom saavel som om Skorpernes Optræden ved de større Søer er der givet nærmere Oplysninger; kun de af Cyanophyceer dannede Skorper er noget nærmere studerede. Paa dobbelt Vis bidrager disse til Dannelsen af Søkalken. Dels bundfælder Algerne den i Vandet opløste Kalk, dels opløser de Kalkstenene og rimeligvis ogsaa Kalken i kalkholdig Flint. Ved Soltørring og Is smuldrer og pulveriseres Skorperne; de herved opstaaede Søkalkaflejringer er paavist af Kirchner ved Bredderne af Bodensøen.

Kalkinkrusterede Sten er underkastede en Corrosionsproces, der ikke alene lader sig paavise paa Kalksten, men formentlig ogsaa paa Flint. Forf. kan absolut ikke tiltræde den først af Forel og senere af Kirchner fremsatte Anskuelse, at Algerne langtfra at angribe Stenene skulde danne et beskyttende Dække over disse. Corrosionen skyldes et kombineret Angreb saa vel af Algerne som af den i disses Skorper levende Dyreverden; ved dette Angreb banes Vej for kulsyreholdigt Vand, der yderligere ætser Stenoverfladen.

7. Ferskvandsmolluskernes Skalstruktur er, for saa vidt den er kendt, nærmere omtalt. Destruktionen af Skallerne er indgaaende studeret; ved Forsøg er det godtgjort, at de organiske Stoffer forsvinder i de gamle, paa dybere Vand aflejrede Molluskskaller, hvorved disse forvandles til en blød plastisk Masse, af hvilken Molluskkalken direkte fremgaar.

Af afgørende Betydning for Destruktionen af Skallerne, særlig inde paa lavere Vand, er Corrosionen af de endnu levende Molluskers Skaller, idet de allerede ved Dyrenes Død mer eller mindre defekte Skaller hurtigere opløses eller pulveriseres. Corrosionsprocesserne er nærmere omtalt (se pag. 44); kalkborende Alger spiller ved Corrosionen en noget større Rolle, end man tidligere har formodet.

8. Den af Organismerne producerede Kalk opstaar hovedsagelig indenfor 11 Meter Kurven; en mindre Del føres i pulveriseret eller opløst Form ud over denne og tilblandes enten de dybere Partier af Søbunden eller føres ud af Søen. Af den Intensitet, hvormed de opløsende og mekaniske Faktorer virker, afhænger Mængden af udflyttet Materiale. Hovedmassen af den saaledes producerede Kalk aflejres i vore Søer formentlig indenfor 11 Meter Kurven. Ved disse Aflejringer opstaar her de urene Søkalkaflejringer: Sømergel, og de mere ublandede: Characeekalk og Molluskkalk; kun disse sidste er nærmere studerede.

9. Ved Studiet af Mergelaflejringerne i Hingesø blev disse erkendte som Characeekalk, en Aflejring, der hidtil har været ukendt hos os, og som iøvrigt er lidet undersøgt.

Characeekalken er her i Landet en Lavvandsdannelse; en af Hovedbetingelserne for dens Fremkomst er, at der paa 5—8 Meter Vand forefindes større, flade Characee-bevoksede Sletter; hvor dette er Tilfældet, foregaar Characeekalk-Aflejringerne endnu den Dag i Dag. I alle de af mig undersøgte større Søer er et særligt Characeebælte paa 5—9 Meter Vand paaviseligt; i dette, der som oftest strækker sig hen over skraanende Søbundssider, til hvilke Bølgebevægelsen endnu naar ned, finder sjældent Aflejringer af Characeekalk Sted.

10. I alle de undersøgte større Søer findes paa 8—11 Meter Vand et heller ikke andet Steds kendt Bælte betegnet som Skalbæltet, hvori Hovedmassen af Søens Molluskskaller aflejres. Bæltet opstaar væsentlig ved Aflejring af de i dette levende Molluskers Skaller, mindre paa Grund af Materiale udflyttet fra lavere Vand. Bæltets Begrænsning udadtil fremkommer ved, at 11 M. Kurven

er den Grænse, hvortil Mollusklivet, Pisidierne fraregnet, i Almindelighed naar ud i vore Søer. Indadtil opstaar Grænsen derved, at de, navnlig i den øverste Del af Vegetationsbæltet aflejrede Skaller, destrueres saa stærkt, at større Aflejringer af tomme Skaller ikke kan opstaa. Grænsen ind ad mod Land er mindre skarp end ud imod Dybet.

Under de rolige Aflejringsforhold i Skalbæltet faar Mollusklivet her Betydning som en stærk lokaliseret, bundhøjnende Faktor, ved hvis Virksomhed Bakkekæder opstaar. Revlignende Skalaflejringer er paavist i Skanderborgsø og Furesø; Iagttagelser i større Søer end dem, der har været Genstand for denne Undersøgelse, vilde i øvrigt være ønskelige.

Paa saadanne Steder, hvor store Mængder af organisk Materiale bundfældes, synes Skallerne at opløses, og der finder ingen Kalkaflejringer Sted. Hvor Bundfældningen af organisk Materiale ikke er synderlig rig, omdannes Skallerne til en plastisk Masse, hvoraf Molluskkalken fremgaar.

Skalbæltets Beliggenhed er i Søens Historie ikke konstant; under dennes Omdannelse fra aaben Sø til Mose og Eng ruller i Tidens Løb Skalbæltet efterhaanden ud over hele Søbunden.

En Del hidtil savnede Oplysninger om de enkelte Molluskarters bathymetriske Udbredning er tilvejebragt.

11. Aflejringer af Sømalm har hidtil været ukendt i danske Søer. Undersøgelsen har vist, at der i Furesøen findes ret betydelige Aflejringer af Bønnemalm, samt at denne lader sig paavise i mange af vore andre større og dybere Søer. Brunjærnstensaflejringer af noget andet Udseende forefindes i Tjustrupsø. Overalt opstaar disse ved Omdannelse af Skalbæltets Molluskskaller, særlig *Valvata, Unio* og *Anodonta.* Processen kan maaske nærmest betegnes som Metamorfose; denne lader sig for Muslingernes Vedkommende forfølge Skridt for Skridt.

12. De Aflejringer, der for Øjeblikket foregaar paa vore dybere Søbunde, bestaar i Overensstemmelse med

Landets Jordbunds- og Naturforhold væsentlig af Ler, Kalk og organiske Stoffer. Alt i længere Tid har Bundfældningen af sidstnævnte Art været de overvejende. Aflejringernes øverste Lag lader sig for alle undersøgte Søers Vedkommende henføre til Begrebet Søgytje. Det dybere Vands rene og ublandede Ler- og Kalkaflejringer (Indsøler og Søblege) hører. for saa vidt de opstod ved en direkte Bundfældning af Ler- eller Kalkpartikler. en svunden Jordperiode til; de er fremkomne paa et Tidspunkt. da Vegetationens bindende Indflydelse over for Jordpartiklerne var mindre end nu. og Søernes organiske Liv fattigere (om Søblegen se dog pag. 91). De hviler for Øjeblikket dybt under de Nutidsaflejringer. vi med Skraben kan naa. Dannelsen af Indsøler og Søblege foregaar dog rimeligvis endnu den Dag i Dag, men i saa Fald som Følge af Bundfaunaens og Bakteriernes fordøjende og omsættende Virksomhed; idet disse Organismer nemlig fjærner de organiske Stoffer af Nutidsaflejringerne. bliver den mineralske Rest: Ler og Kalk. tilbage. (Se videre under 20 samt Anm. p. 129 og 142.)

13. Ved Gytje forstaas de særlig overfladiske Dynddannelser. der opstaar paa Bunden af rene. klare Vande. og som indeholder betydelige Mængder Ler og Kalk, er af koprogen Beskaffenhed og kun for en ringe Del bestaar af ufordøjet Materiale.

Fællesbundfældningen. hvoraf Gytjen opstaar. er af 4-dobbelt Oprindelse: 1. Pulveriseret organisk Materiale. stammende fra Vandmassens og det tilgrænsende Landskabs Dyre- og Planteverden. 2. Pulveriserede uorganiske Stoffer. hidført af Floderne eller løsnet af Brændingen. 3. Atmosfærisk Støv. 4. Kemisk Udskillelse af de i Vandmassen opløste Stoffer.

Idet denne Fællesbundfældning fordøjes af Søbundens Organismer, skifter den Farve fra sort til graa og betegnes nu som Gytje.

Hovedbetingelsen for dennes Dannelse er. at der af organisk Materiale ikke tilføres større Kvantiteter end Søbundens fordøjende Elementer er i Stand til at omdanne til Ekskrement eller yderligere omsætte. Tilføres organiske Stoffer i for stor Mængde, opstaar sort Dynd (Floddeltaer etc.) Konserveres det tilførte Materiale paa Grund af Vandmassens Rigdom paa Humussyrer, opstaar Tørv.

14. For Søernes Vedkommende skælnes der mellem to Slags Gytjer: den ude paa Dybet opstaaede Søgytje og den paa lavere Vand, navnlig ved Aflejring af grovere Vegetationsmateriale og Snegleekskrementer opstaaede Strandgytje.

Mellem Lavvandets Aflejringer: Sømergel, Strandgytje og Tørvedannelser, gives alle tænkelige Overgange.

Søgytjen karakteriseres ved at indeholde Rester af typiske Planktonorganismer, særlig Diatomeer, blandt hvilke fremhæves *Stephanodiscus Niagaræ, Melosira crenulata* og *granulata* samt undertiden *Asterionella gracillima.*

Om Søgytjens uorganiske Bestanddele, se 12; kun tilføjes det, at Kalkprocenten i vore forskellige Søgytjer er meget forskellig, men ofte meget høj (c. 25—60 %). Af de organiske Bestanddele er særlig de, der stammer fra Plankton, nærmere studerede.

Ud fra Kendskabet til dette lader forskellige Typer paa Søgytje sig opstille.

15. En Søs Plankton afhænger af Søens Naturforhold, og Gytjen er atter afhængig af Planktonets Beskaffenhed.

Idet der af Planktonorganismerne kun bundfældes Skeletdele, bliver det Skeletdelene af de Planktonorganismer, der danner de højeste Maksima i Søen, der har afgørende Indflydelse paa Søgytjen.

Planktonorganismernes Skeletdele dannes af Kiselsyre, Kutin, Kitin, Cellulose og kulsur Kalk.

Alt eftersom en Sø i Følge sine Naturforhold er i Stand til at yde de bedste Livsbetingelser for Kisel-producerende eller for Kutin-producerende Organismer (Diatomeer og Cyanophyceer), opstaar der i denne enten et overvejende Diatomeeplankton eller et overvejende Cyanophyceeplankton. Idet Cyanophyceerne for at opnaa deres store Maksima over længere Tidsrum kræver en Vandtemperatur paa c. 17—19° C., bliver disse kun dominerende i de varme Søer; Diatomeerne, hvis Maksima ligger ved c. 10—12° C., derimod i de kolde. Kun sjældent opnaar Diatomeer og Cyanophyceer paa et og samme Tidsrum i Søens Historie lige høje Maksima i denne (Cyanophyceerne aldrig i de kolde, Diatomeerne i Vinterhalvaaret undertiden i de varme). I Overensstemmelse hermed opstaar i de varme Søer med høje Cyanophyceemaksima Cyanophyceegytjen, i de kolde Søer med høje Diatomeemaksima Diatomeegytjen.

De Kitin-producerende Organismer opnaar høje Maksima saavel i varme som i kolde Søer, og deres Skeletdele tilblandes baade Cyanophycee- og Diatomeegytjen; i mindre, lave Søer dominerer dog de Kitin-producerende Organismer (især Crustaceer) saa stærkt, at Kitingytjer opstaar.

Den kulsure Kalk spiller en ganske underordnet Rolle med Hensyn til Skeletdannelsen hos Ferskvandets Planktonorganismer; disse bidrager derfor i Modsætning til Hav-Planktonet saa godt som ikke til Søbundens Kalkaflejringer; Celluloseskeletterne spaltes og forsvinder af Søbunden.

16. Talrige Forhold bevirker, at Blandingsgytjer mellem de tre opstillede Typer nødvendigvis maa fremkomme. At fuldkommen rene Typer ikke kan opstaa, fremgaar alene deraf, at der i enhver større Søs Plankton er Repræsentanter til Stede for alle Plankton-dannende Dyre- og Plantegrupper, og at der altsaa til enhver Tid finder Aflejringer af yderst forskelligartede Skeletdele Sted; faktisk gives der Søer, hvis Plankton er af saa uensartet Beskaffenhed, at udprægede Blandingsgytjer opstaar alene paa Grund af Planktonets Natur. I de allerfleste Tilfælde optræder dog Hovedmassen af en Søs Planktonorganismer i et saa ringe Individantal, at disse ved Søgytjens Sammensætning praktisk set ingen

Betydning har, samtidig med, at ganske enkelte, ofte nær beslægtede Former danner den alt overvejende Del af Søens samlede Planktonmængde. Selv i de Søer, hvor dette er Tilfældet, og hvor mere ublandede Søgytjer kunde ventes, gives der dog en Række Forhold, der bevirker Uensartethed mellem Gytje og Plankton, og hvorved Blandingsgytjer opstaar.

Af saadanne Forhold fremhæves særlig følgende:

a. Mængdeforholdet mellem en Søs Phyto- og Zooplankton genfindes ikke i Søgytjen; Hovedmassen af Zooplankton bundfældes nemlig paa dybere Vand, en Del af Phytoplankton derimod inde paa lavt Vand eller udføres af Søen.

b. I Bundfaunaens Fordøjelseskanaler omdannes Skeletdelene ulige stærkt; rimeligvis fordøjes Cellulosen; Diatomeeskeletterne gaar uskadte igennem.

c. Floder, der optager Tilløb kommende fra Søer med andet Plankton, fører dette med sig og aflejrer det i de Søer, som deres Løb gennemstrømmer, og hvis Søgytje derved modificeres.

d. Bortset fra den Omdannelse, Skeletterne undergaar under Fordøjelsesprocessen, konserveres de ulige længe og paa forskellig Vis; længst bevares Diatomeerne, der aldrig ganske synes at mangle i Søgytjen.

17. Om der end navnlig paa Grund af disse Forhold opstaar talrige Blandingsgytjer, lader de tre opstillede Typer paa Søgytje sig meget vel opretholde; ude i Naturen vil man, som Tavle 3 viser, kunne støde paa Søgytjer, for hvilke Betegnelserne: Diatomeegytje, Cyanophyceegytje og Kitingytje er fuldt forsvarlige. Af Grunde angivne pag. 102 har jeg villet undgaa en for skarp Definition af disse Begreber.

Diatomeegytjen dannes næsten udelukkende af Planktondiatomeer; typiske Bundformer spiller en ganske underordnet Rolle og er rimeligvis forslaaede Kystindivider.

I Følge Forel og Kirchner mangler Diatomeerne, navnlig Planktondiatomeerne, næsten ganske paa Bunden af de dybe Schweizersøer; rimeligvis opløses de under Nedsynkningen gennem den 2—300 M. høje Vandsøjle; i vore lave Søer finder ingen Opløsning Sted, og de mægtige Aflejringer af Diatomeeskallerne kan saaledes foregaa (Haldsø).

18. Ved Tilblanding af uorganiske Stoffer opstaar de stærkt uorganiske Søgytjer: Cyanophyceeler, Diatomeekalk, Diatomeeler; se nærmere pag. 123. Om den af mig foreslaaede Terminologi vedrørende de dybere Søbundsaflejringer se pag. 124.

19. Den i vore Søbunde levende Fauna er gennemgaaende den samme som den af Forel paapegede for Schweizersøernes Vedkommende: den er endnu ikke tilstrækkelig undersøgt, men Arbejder herover er under Forberedelse. Overfor Bundartens Beskaffenhed spiller Faunaen en dobbelt Rolle. Den er dels selv bundhøjnende og bidrager til Dannelsen af de Elementærbestanddele, hvoraf Gytjen opstaar, dels er dens Virksomhed af en fordøjende Natur, hvorved disse Bestanddele omdannes til Ekskrement.

20. Alene ved Undersøgelsen af det Materiale, Skraben bringer op, kan man paavise tre forskellige Lag i vore dybere Søbunde; øverst ligger den brunsorte Fællesbundfældning, der næppe endnu kan betegnes som Gytje; under denne et gult stinkende Lag, hvori stærke organiske Omdannelsesprocesser foregaar; nederst den gennemekskrementerede paa uorganiske Stoffer rige, færdigbearbejdede Søgytje, graablaa af Farve og uden synderlig ilde Lugt; dybere nede og jævnt gaaende over i denne ligger formentlig det koprogene Indsøler. En finere Lagdeling, svarende til det til de forskellige Aarstider bundfældede uensartede Materiale, gaar paa Grund af Bundfaunaens ekskrementerende Virksomhed derimod tabt.

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21. De fleste af de i dette Arbejde behandlede Spørgsmaal er væsentlig kun bleven betragtede fra zoologiskbotaniske Synspunkter, men vil inden de underkastes en

kemisk-hydrografisk og bakteriologisk Undersøgelse ikke kunne siges at være tilstrækkelig belyste.

Visse Sider af Undersøgelsen har jeg med Forsæt udelukket fra Behandling. Saaledes er Kysternes Vegetationsaflejringer, uagtet de hverken skarpt lader sig afsondre fra Sømergelaflejringer eller Strandgytjer, ikke gjort til Genstand for Omtale. Ligeledes mangler i dette Arbejde alle Oplysninger om vore Søbundes ret betydelige Sandsletter og Stenaflejringer, der navnlig i Furesøen er meget fremtrædende. Vegetationsaflejringerne lader sig imidlertid ikke ret vel studere uden i Sammenhæng med de af Danmarks geologiske Undersøgelser paabegyndte Studier over Fortidens Vegetationsaflejringer, Tørvedannelser etc.; det har derfor været naturligt her ikke nærmere at gaa ind paa Nutidens Vegetationsaflejringer. At give en Skildring af vore Søers Sandsletter og Stenaflejringer har vist sig at være umulig, inden Søernes Bunde er bleven kortlagte.

22. Kortlægningen af vore Søers Bund er en Opgave, der hører Fremtiden til. Det er ikke saa faa videnskabelige Undersøgelser, der maa udskydes, indtil saadanne Kort foreligger, og at de iøvrigt for en hvilkensomhelst Undersøgelse vedrørende vore ferske Vande vilde have den største Betydning, er indlysende; men desforuden maa de nødvendigvis være af Vigtighed for et rationelt Ferskvandsfiskeri.

Det synes nu, da en videnskabelig Undersøgelse af vore ferske Vande efter Oprettelsen af det Ferskvands-biologiske Laboratorium har taget sin Begyndelse, og da der fra forskellige Sider gøres meget for at ophjælpe det hidtil stærkt forsømte Ferskvandsfiskeri, at det Tidspunkt maatte være kommet, da en saadan Kortlægning burde tage sin Begyndelse.

Til de øvrige Grunde for Paabegyndelsen af et saadant Foretagende kommer imidlertid ogsaa den, at disse Kort maatte have en ikke ringe geologisk Interesse. I de senere Aar er videnskabelige Undersøgelser over vore Have og Jordbundsforhold paabegyndte, og Resultater baade af videnskabelig og praktisk Betydning foreligger. Ingen Del af vort Land er saa lidet undersøgt som vore ferske Vande. ingen Del i saa ringe Grad udnyttet; ogsaa ud fra en geologisk Betragtning lader der sig paapege vægtige Grunde for, at vore Søbunde ikke i Længden bør ligge som ukendte Enklaver i iøvrigt færdigundersøgte Landstrækninger.

Efter at foregaaende var sat modtog jeg fra Hr. LYBEK endnu den pag. 131 i Anm. omtalte mere dybtgaaende Bundprøve fra Bunden i Loldrupsø. Hr. L. skriver mig til, at han først tog en Bundprøve direkte fra Søbundens Overflade og c. 2 Alen ned; derpaa tog han en anden i et af de gravede Huller. hvorfra der tidligere af Mergelgraverne var borttaget c. 2 Alen af Mergellaget; ogsaa denne Prøve blev c. 2 Alen høj; tilsammen skulde de mig tilsendte Prøver altsaa repræsentere en Jordsøjle paa c. 4 Alens Højde.

Ca. 1 Alen fra Søbundens Overflade viser Prøven et stærkt sandblandet Skallag. hvor Skallerne. særlig Muslingernes, var overordentlig plastiske og bøjelige og ved Tilsætning af Vand nærmest henflydende. Min pag. 77 udtalte Formodning. at ældre dybtliggende Skallag indeholdt plastiske. kridtagtige Skaller. er herved bleven bekræftet. Ogsaa i disse to Prøver skiftede Farven ovenfra nedefter fra sort til graablaa eller lysegraa. 3 Alen nede var Farven graagul. det nederste Kvarter af Bundprøven graablaa, men af en lidt mørkere Farve end det Lag. der laa over det graagule Parti. Pillens øverste Lag bruste aldeles ikke for Syrer; Brusningen begyndte først længere ned, og alle Prøver fra c. 1 Alens Højde og nedefter bruste meget stærkt. Set under Mikroskopet viste de øverste Lag store Mængder af Dyre- og Plantelevninger, særlig Diatomeer; enkelte af disse lod sig endnu paavise i c. 1 Alens Dybde, men i de nederste Partier af det øverste blaagraa Lag lod de sig ved denne foreløbige Undersøgelse aldeles ikke paavise; det graagule Lag, der navnlig nedadtil var ret skarpt begrænset, indeholdt talrige Planterester. Det underliggende blaagraa Lag viste under Mikroskopet ikke Spor af organiske

Bestanddele; det bruste overordentlig stærkt for Syre og syntes at være af en finere pulveriseret og mere ensartet Beskaffenhed end de øvrige Lag.

Desværre var dette nederste Lag ikke skaaret igennem, og Prøven indbefattede ikke de hvide ovenfor omtalte sandblandede Lag. Der er dog en Mulighed for, at det brungule paa Planterester rige Lag adskiller det underliggende Lag af Glacialler fra det overliggende Lag af koprogent Ler, der jævnt gaar over i de øverste paa organiske Aflejringer yderst rige Overfladedannelser.

Den foreløbige Undersøgelse af disse Bundprøver bekræfter i høj Grad, hvad jeg pag. 96 hypothetisk fremsatte angaaende Dannelsen af Nutidens koprogene Indsøler- og Søblegeaflejringer.

Ferskvands-biologisk Laboratorium
ved Furesø.
Frederiksdal pr. Lyngby.

Efterskrift.

Efter at jeg i et Foredrag den 12. Decbr. i Geologisk Forening udførligere havde gjort Rede for Søkalkens Dannelse og Oprindelse og bl. a. særlig havde omtalt Characeekalken, meddeltes der mig kort før nærværende Arbejde gik i Trykken, at der af C. A. DAVIS i Journal of Geology, Vol. VIII September-Oktober Hæftet 1900, var publiceret to Afhandlinger vedrørende Søkalkaflejringer og betitlede: *A contribution to the natural history of marl* (pag. 485—497) og *A remarkable marl lake* (pag. 498—503). Det viste sig, at det særlig var Characeekalken, DAVIS har undersøgt; paa flere Punkter falder vore Iagttagelser herover sammen, paa adskillige andre supplere de hinanden.

Da jeg ikke kunde omarbejde mit Manuskript, der laa færdig til Trykning paa det Tidspunkt, jeg lærte DAVIS Arbejder at kende, valgte jeg i en Efterskrift udførligt at omtale de af ham foretagne smukke Undersøgelser. Se herom Slutningen i det engelske Resumee; DAVIS Afhandlinger har her givet mig Anledning til et Par Bemærkninger, som ikke findes andet Steds i Arbejdet.

18—4—1901.

Summary of contents.

At the FRESHWATER BIOLOGICAL LABORATORY ON FURESØ investigations have been carried on during the last two years as to the different deposits occurring in the beds of the Danish lakes. Among these 14 of the largest and deepest, varying in size from 5 to 34 □ kilom. and in depth from 8 to 40 m. were selected, to the exclusion of such lakes, where a connection with the sea could be proved to have existed up to a recent date. Furesø, size 9 □ kilom., depth 33 m. was particularly explored.

This paper will give the results of the investigations of the lime deposits, pea-ore (»Bohnerz«) and the bottom mud of the lakes, the latter taken in the limitation given by v. POST and by him termed lake-gytje.

Kap. 1. The lime producing organisms and the calcareous deposits of the lake bottom.

It may be assumed, that the water brought by streams and springs into larger lakes is always subjected to a decalcination mainly arising from three causes: A mechanical dropping down of calcareous particles suspended in the water; a chemical precipitation of lime held in solution by carbonic acid; the agency of organisms, which fix the lime in their tissues and deposit it in the shape of calcareous coatings and skeletons.

Owing to this decalcination the calcareous deposits of the lakes arise. Physical and chemical explorations of our freshwaters being as yet wanting, we shall here principally restrict ourselves to an investigation of lime-deposits, whose origin may be traced to the agency of organisms, hoping that physical-chemical explorations will before long elucidate the former two. In classifying the different kinds of lime-deposits found in freshwater, I have used the following terms: lake-lime, calcareous tufa formed in springs, and moor-lime »Wiesenmergel«. Of these we shall only consider lake-lime in this paper.

One of the main results of the investigations has been to point out the fact, that the lime-producing organisms of our lakes with very few exceptions do not go out beyond the 11 m. curve. The lime-deposits in- and outside this curve in all probability differ somewhat as to their origin. Whilst the deposits inside the curve must be supposed to have arisen mainly from the pulverization of local lime-producing organisms, the lime-deposits outside the curve have either been formed by the dropping down of lime particles held in suspension in the water or by precipitation of lime held in solution by carbonic acid; lime-deposits derived from pulverised lime-skeletons secreted by organisms living in the deeper parts of the lake will here undoubtly only be of minimal importance.

In accordance with these facts I have further classified the lake-lime as follows.

The lime-deposits outside the 11 m. curve, when comparatively pure and unmixed I have termed »lake-blege« (Søblege) and when strongly mixed with clay and organic matter »lime-gytje«. The lime-deposits inside the 11 m. curve, when comparatively pure and unmixed I have termed Characee-lime or Mollusk-lime and when impure lake-marl.

The freshwater lime-deposits may in our lakes accordingly be classified as follows:

I. Lake-lime.

Lime-deposits outside 11 m. curve.	impure (20—80 % $CaCo_3$).	*Lake-gytje.*
	pure (more than 80 % $CaCo_3$).	*Lake-blege.*
Lime-deposits inside 11 m. curve.	impure (20—80 % $CaCo_3$).	*Lake-marl.*
	pure (more than 80 % $CaCo_3$)	*Characee-lime.* *Mollusk-lime*

II. Calcareous tufa formed in springs (Kildekalk).

III. Moor-lime (Mosekalk »Wiesenmergel«).

The lime incrustations of aquatic plants.

It is a wellknown fact, that many freshwater plants precipitate calcium carbonate on their leaves and stems; among these *Chara* is the most predominent, the lime not only coating the plant, but being probably deposited in the cellular tissues also. P. 12 the different plants have been mentioned on which incrustations have been found as well as those, where I have looked for them in vain. As to the origin of the incrustations see: PRINGSHEIM, HASSACK and KOHL, who have set forth their separate opinions on this point.

The precipitation of lime effected more especially by *Chara* plays an essential part in the formation of lake-lime. In spring the incrustations are only slight, but in the course of summer they increase in thickness and in autumn the lime drops off in great quantities from the floating islets of *Myriophyllum* and *Ceratophyllum*; on *Potomageton lucens* the coatings last til late in the year and may still be found on *Elodea* in shallow water after the frost has set in. The incrustations on the plants of a given lake are at no time of the year equally heavy; even plants of the same species are not incrusted to the same degree in the different parts of the lake. On *Elodea* and *Fontinalis* at the depth of 8—10 m. (Furesø) no traces of lime-coatings occur throughout the seasons of the year. In shallow water the limecrusts of the latter increase in thickness, according as the plants rise to the level of the lake, so that the leaves near the surface are most heavily covered. When the plant dies, the crusts fall off. No lime incrustations occur on plants that grow in swiftly running water. The degree of incrustation greatly depends on the shape of the organ of assimilation. The precipitated lime does not accumulate to the same extent on vertical and cylindric organs as on horizontal planes; it is most conspicuous on the upper side of the leaves, but if the under side, owing to outward influences (webs of insects) is turned up, this side will become incrusted; on the floating leaves of *Nymphæaceæ*, *Hydrocharis* etc. no crusts appear, probably owing to mechanical conditions; they occur on the submerged leaves of *Nymphæa*.

The lime incrustations (with the exception of the Characees) are not as reported by Hassack solid, adhesive crusts, which when once formed will continue to cover the stems and leaves; drifting plants of *Elodea* and *P. lucens* present no lime coatings, though the corresponding plants growing c. 70 m. off the beach are heavily overlaid; the stroke of an oar amidst the thick growths of *P. lucens* will make the lime drop off abundantly. Where cornetlike depressions occur in leaves or between leaf and stem, the cornet is seen filled to the rim with lime powder dropping down from the plant into these receptacles. In August the large tops of *P. lucens* and *perfoliata* in Furesø are covered with the delicate web of a Phryganee larva; the lime-particles, as they fall are caught in the net, and the tops of the plant not being able to carry the heavy weight, the stems will bend downward in great curves. Owing to some mechanical action or other, parts of the crusts break off, but are soon replaced by new flakes of a thinner structure than those on the other parts of the leaf, and in this manner a terraced series of layers will form. The thicker flakes may be detached and will show traces of nerves, possibly even of the epidermis-cells of the leaves on their smooth underside. The outerside of the crust is rough with numerous small pointed faucets consisting of lime-particles. — Owing to the above observations I have been led to interpret the process of incrustation somewhat differently to other investigators:

In clear, calm weather the lime accumulates in thick flakes on leaves and stems, but is swept off in stormy weather by the wave action. The precipitation probably goes on unceasingly during the assimilation; the leaves not being able to carry the full weight of the lime continually drop broken particles, which will sink to the bottom at a shorter or greater distance from the plant. The thickness of the limecrusts is depending on the conditions of light; they will be thickest on those plants or parts of plants, that are exposed to the strongest light. In order to show as far at it was practicable, that the precipitation of lime owing to the *Potomogeton* and *Elodea* play a prominent part in the formation of lake-lime, two bottom samples were taken in Furesø, one from a bed of *P. lucens* and *Elodea*, the other from a depht of 33 m., the former containing 72.41 $^0/_0$ the latter 35.30 $^0/_0$ of lime, viz. less than one half; yet it must be remembered, that the mollusks of the vegetation-zone will raise the lime amount of the first sample. On separately weighing the dried leaves of *P. lucens* and their coatings it appeared, that a leaf often carried more lime than its own weight; one leaf weighing 0.35 gram carried no less than 4.1 gram of lime; as one plant has often some 30 leaves, their joint amount of lime would be considerable. The deposits underlying the *Characeæ* growths are mainly owing to dead plants and broken remnants, which sink to the bottom and settle there.

Crustforming, stonecovering blue-green algæ.

The stones along the shores of our lakes are often more or less covered with crusts, which in most cases are the work of lime-incrusted algæ of the genus *Schizotrix* and *Rivularia*. The thin, white coatings seen in spring are however often due to the *Diatoms*, others to certain species of green algæ (*Cladophora).* The crusts are often overlaid by other algæ colonies, *Rivularia rufescens*, *Pleurocladia lacustris* etc. We shall here only consider the incrustations of the blue-green algæ.

The crusts chiefly occur on the stones of shallow water, rarely at the depth of 1 m. below the surface and often 2 m. above the ordinary summer waterline. With us they do not cover the stones to the same extent as on the shores of the Bodensee and Genfersee and play a less predominent part in our lakes. Concerning the hygroscopic property of the calcareous crusts, their chemical compound and the relations they bear to the algæ, see KIRCHNER; here we shall only consider their co-operation in the formation of lake-lime.

As to the question, from what source the calcium carbonate of the algæ-crusts is derived, the algæ have two ways of acquiring the lime: one, as the above mentioned plants by precipitating it from the water, the other, by abstracting it from the substratum on which they grow. Yet observations from nature prove, that the crusts prevail to the same extent, whether the algæ happen to grow on flint, granite or lime; it must then be concluded, that the algæ principally precipitate the lime from the water, and that the substratum at any rate is of secondary importance. On the other hand an examination of the stones prove them to be subjected to a mouldering process of decay. The different authors all agree as to the corroding influence of water upon the surface of stones, but as to the agency of algæ in this respect, two differing opinions obtain. According to Forel and Kirchner the corrosion of the stones is owing to the fauna living in the algæ-crusts; according to these authors the algæ themselves far from exercising any destructive influence rather serve to protect the stones, whereas Chodat asserts, that the algæ are the main cause of destruction, the agency of the animals being to his opinion of minor importance. Evidently the algæ crusts are exposed to attacks from without, and to such the meandric ridges and holes on their surface must be ascribed; in our comparatively small lakes, where of course the surf action must be less vigorous, than as recorded by Kirchner on the shores of Bodensee, the perforated surface of the algæ crusts is mainly due to the work of animals, principally Amphipodes, snails (*Neritina, Limnæa auricularia*) a few herbivorous Phryganees (*Goëra, Molanna*), *Ostracoda* and *Copepoda.* — *Rhyacophila*, *Ephemeridæ, Perlidæ* and the larvæ of gnats, to whom the holes are generally ascribed, are all carnivorous animals, that do not subsist on the algæ; they possibly repair their hidingplaces, but can scarcely be supposed to live a burrowing life in the crusts, their mandibles and the structure of their legs are certainly not suggestive of it.

The question then is, whether the above fauna is also conducive to the corrosion of the very stones on which the algæ grow. Forel and Kirchner, who maintain this, are of opinion, that the animals by gnawing the algæ crusts give the water admittance to the surface of the stone, that they afterwards burrow in the corroded parts, and further increase the dissolving properties of the water by saturating it with carbonic accid arising from their respiration; though much may be said in favour of this theory, the two authors in my opinion take a rather onesided view of the case in stating, that the algæ even exercise a protecting influence with regard to the stones. Chodat distinctly points out, and my own observations in a great measure corroborate his statement, that the algæ are often active agents in the corrosion of the stones; on this point I agree with Chodat, the more so, as I have observed, that the stones on the shores of lakes, where incrustations occur, are more corroded, than where they are wanting, and in my opinion particularly so on those parts of the shore, where the crusts are most predominent. Moreover it seems improbable that vegetable coatings, otherwise exercising a disintegrating and pulverizing influence upon stones should in this case constitute a protecting covering. However I think that CHODAT has somewhat underrated the signification of the fauna.

The mouldering process depends chiefly on the petrografic qualities of the stone; to the present day only the algæ-coatings on lime stones have been studied. In Denmark it seems that the corrosion of flint takes a slower course, but as to the final result no less destructive. Even on black flint a whitish crust is seen under the algæ, but whether this is owing to the corroding agency of the algæ or is only the white crust common upon flint must as yet remain undecided; yet it is a fact that the lime incrusted flints along the shores of Furesø are being subjected to a corrosion of an intensive description. If it be remembered, that all flint, even black flint, contains calcium carbonate in the shape of calcareous spar, it seems by no means incredible, that the algæ derive some practical gain from the substratum, even if this be flint — as also, that when particles of the calcium spar have been dissolved by the agency of the algæ, the substratum may be said to undergo a corrosive process due to the algæ.

My opinion as to the correlations of the lime-incrusted algæ and the stone surfaces is then as follows:

On part of the algæ as well as of the animal organisms a joint assault is made on the surface of the stones, which by this means are perforated and corroded; whether the plants or the animals are the most active agents can scarcely be determined; at one period the former probably have the upper hand, at another the latter; the petrographic quality of the stone is here undoubtedly of some moment. The first attack is unquestionably due to the algæ; subsequently the animals by opening a way for the water to the surface of the stone, and by excavating the corroded parts, have a great share in the further process of decay.

Lake-lime deposits owing to the agency of lime-incrusted algæ arise partly from the bursting and pulverization of the sun-dried coatings, and partly from the grating of the ice, which scours the crusts off the stones. Lime-deposits of this description do not occur in our relatively small lakes. KIRCHNER records them as occurring on the shores of the Bodensee.

With regard to the stone-covering algæ I have been able to demonstrate, that the incrustations are most copious on the shores of those lakes, where the lime percentage of the bottom soil is high, and wanting where it is low or 0.

Lime-producing animal organisms.

In freshwater the only animal organisms of special importance as lime producing factors are the mollusks. The snails prevailing in our larger lakes belong mainly to the genera: *Unio*, *Anodonta*, *Pisidium*, *Bithynia*, *Valvata*, *Neritina*; and of *Limnæa* only: *L. auricularia, ampla, ovata*, — more rarely *L. stagnalis* and some small species of *Planorbis*. Only these forms play an essential part in the formation of lake-lime.

The lime secreted in the shells of mussels does not proceed from exactly the same source as that secreted in the shells of snails, the mussels being able directly to fix in their tissues the lime held in solution or suspension in the water, whereas snails can only utilize the lime already deposited in other organisms. A well known characteristic of snails is their predilection for lime; the immense number of freshwater snails occurring upon Charagrowths and on lime-incrusted higher plants may be instanced in this connection. Though covered with the excrements of snails, the colour of which is about the same as that of the lime crusts, the leaves of the plants are but slightly injured; the snails only seem to relish the lime and deposit it as a protecting skeleton surrounded by organic matter. Though the structure of the mollusk-shells varies greatly, one feature is common to all, viz. that the lime is secreted between membranes of an organic substance, generally termed conchyolin and in close affinity to chitine. As an additional coating the shell is often furnished with a thick cuticle *(Periostracum)* which is particularly the case with freshwater mollusks.

The fundamental difference existing between the above mentioned respectively by plants and by mollusks precipitated lime will be, that the lime produced by plants (partly with the exception of the Characees) not surrounded by organic membranes will quickly be dissolved in the water, whereas lime produced by animal organisms being surrounded by organic matter is only dissolved by slow degrees and after a long space of time.

By what process then is the dissolution and pulverization of the shells brought about, and how do we account for the formation of lake-lime originating from the deposits of shell débris in the bed of the lake?

On examining the empty old shells of mussels it will appear, that they are all more or less in a state of decay; the cuticula is often wanting, and the prismatic layer, which as a granular powder partly covers the exposed parts of the shells, is often more or less falling away (tab. I fig. 9); the further corrosion of the shell takes place intermittantly, the conchyolin lamels preventing the uninterupted course of the process. On the sides of the grooves often found in decaying shells a terraced succession of lime and conchyolin layers may be observed.

On taking such old shells of mussels or snails f. ex. *Valvata piscinalis* and submerging them in PÉRÉNYIS liquid, the lime will be dissolved in the course of a few minutes and the whole shell literally have disappeared. The shells of living individuals take several hours in dissolving, and in the acid the remaining organic parts will indicate the outline of the shell. The difference between the subfossil and the recent shell consequently is, that in the former the conchyolin and the cuticula are wanting. A considerable number of old shells in the deeper parts of the lake bottom are generally found in a peculiar plastic and pliable state; in such old specimens neither cuticula nor conchyolin layers are observable; this condition probably sets in, when the organic substance has wholly disappeared. The next stage will be the total dissolution and smouldering away of the shell, conclusively resulting in the formation of Mollusk-lime. Probably the course of the process may vary slightly in the different species, our difficient knowledge regarding the structure of mollusk-shells more particularly freshwater mollusks, prevents our pursueing this subject.

By Conchyologists it is an often observed phenomenon, that the cuticula in still living animals has given way, and that the further corrosion of the shell consequently is in progress. It will be easly understood, that the formation of Mollusk-lime will be greatly accelerated, when the shells already at the death of the animals are in a more ore less fragile condition, being thus more exposed to the corrosive powers of the water as well as to mechanical influences involving the smouldering away of the shell. Hitherto the corrosion of shells of live animals has been studied merely as a conchyological curiosum without any appreciation of the circumstance, that the corroding factors are Natures principal instruments in the pulverization and dissolution of lime precipitated by animal organisms. I have tried to throw light upon the agency of these factors and to point out their signification. As to literature I must refer to page 41—44 and shall here confine myself to my own observations.

In studying the corrosion of shells it becomes evident, that two wholly different agencies must be considered, one causing the rupture of the cuticle, and the other the dissolution of the lime. The former comprises pebbles and gravel, attacks of other snails and algæ, the latter principally the acidity of the water and the acids proceeding from the roots of the plants.

As has often been recorded, snails living in water poor in lime steal it from each other by eating the houses of their neighbours. Large tufts of algæ will cause a depression in the place of growth, but no corrosion will take place, as long as the cuticle remains unimpaired. When it is broken off or severely damaged, the further dissolution of the lime will in most cases be owing to the greater or lesser acidity of the water; many a shell bears witness to the struggle carried on by the animal in preventing the lime from being dissolved as fast as it has been secured. The mussels, on which it will be most easy to follow the process, repair the damage by adding one conchyolin lamel on top of the other over the bare parts of the shell and contrive to secrete lime between them. Mussels are often found in lakes and ponds, where the animals are no longer able to procure the necessary lime for their houses, and where thick chonchyolin lamels form the only means of defence against the surrounding element. On such shells various attempts at repair may be observed. (Tab. I Fig. 7.)

A special kind of corrosion is brought about by certain »lime-boring« algæ. These have already been found in mussels by CHODAT and are also common in this country in shells from 8—10 m. The corrosion seen on *Planorbis corneus* (tab. I fig. 1—6) is probably due to algæ. The shells are covered with a green coating of algæ, from which processes penetrate into the shell. Through the orifices thus produced, the algæ spread radially and circular grooves are formed in the shell substance; while the snail is alive the bottom of the groove remains intact, but when the animal dies it is dissolved, and the shell will be reduced to a network and smoulder away.

The corrosion is most intensive in bogs and ponds and particularly conspicous in early spring and in autumn. In winter, when the humic acids owing to the frost are precipitated in white floccular particles covering the bottom, the additional acidity of the lower layers of the water will probably promote the process of corrosion. The older parts of the shells are most liable to decay. Where the bottom consists of mud, the corroding factors are more predominating, than when it consists of sand. After the death of the animals the further decomposition is essentially promoted by the same factors.

Consequently the corrosion on shells of live animals will in the first place cause the empty shells to be more exposed to the dissolving influence of the water, by whose agency the lime secreted in the shell will be set free and given back to the water, and secondly the already damaged shell will be more apt to smoulder away and be reduced to powder by which the calcareous deposits of the lake bottom will be increased. Outer circumstances (surf, acidity of the water, bottomsoil etc.) cause the destruction of the shells in one of the above mentioned ways. In shell-deposits occurring in deep water the process of decay is very slow; the organic membranes etc. disappear, and the shells will gradually by converted into a pliable substance from which the special sort of lake lime Mollusk-lime arises; in shallow water the shells will be much sooner dissolved and pulverized (see the section treating upon Mollusk-lime).

The lime-deposits.

From the above it will appear, that in our more extensive lakes four special groups of lime-producing organisms may be distinguished: The higher plants, the Characeæ, the blue-green stonecovering algæ and the mollusks; by the agency of these factors lime is secreted and deposited either as an outer coating or between membranes of organic matter within the body of the organisms. The various methods of decomposition having been mentioned, we shall now discuss the different lime-deposits.

The lime producing organisms of our lakes do not range beyond 11 m., and the lime produced in the lakes is formed within this curve. A great quantity of lime will in a pulverized or dissolved state be carried out beyond this curve and be intermixed with the sediments of the deeper parts of the lake or be carried out of the same. Lime-deposits of this origin will be described in the chap. on »lake-gytje«. The lime deposited inside the 11 m. curve becomes intermixed with substances of various kinds: sand, clay, organic matter; so that deposits consisting of different components are formed. Among these peat deposits, lake-marls and shore-gytje, which will be mentioned in the following are the most predominent. As lake-marl I include the impure lime-deposits specially rich in organic matter and occuring in shallow water; they are common in most of our larger lakes at 5—8 m. In an ideal walk across the bottom of the lake the three above mentioned deposits would in due succession be traversed; near the shore the lake-marl gradually changes into peat, further out in the deeper parts of the lake into »shore-gytje«. Local conditions often effect changes, so that one of the three deposits may be substituted by one of the other two, or that all may be represented by some special formation characteristic of the particular locality. Among these two must specially be mentioned: the Characee lime and Mollusk- or shell-lime. Both these deposits owe their origin to the circumstance, that the above organisms have spread and increased at the expence of all others, and that the local circumstances have been such as to render the sediments relatively pure and unmixed. The Characee-lime occurs principally at a depth of 4—9 m.; certain conditions are essential to the formation of Characee-deposits. The study of lake-marl in the signification here applied being closely allied to the study of peat, which has not been included in these researches, we shall here only discuss the pure lime-deposits in shallow water: Characee- and Mollusk-lime, passing by the several more complicated lake-marls.

The Characee-lime.

Considerable deposits of Characee-lime occur in a lake 3 kil. in length and 4—5 m. in depth: Hingesø in central Jütland. The upper layer of the bottom soil consists of a bed of mud well stocked with mollusks, the lower strata gradually changing into a more solid greyish peat; underlying this is a bluish grey bed of lime-deposit, measuring 2—3 m. in thickness and resting on a solid layer of peat. On placing the fresh lime in a sieve numerous small tubular fragments will remain; these tubules measure c. 1. cm. in length and are of a bluish grey colour, rough on the outside and often ridged by 14—16 longitudinal lines. They occur in two types, one in section showing only a circle the other of a more complicated structure, in section 10—20 smaller circles concentering a larger central tube; the tubules are most conspicuous in the upper part of this layer gradually decreasing in numbers downwards, the lower parts consisting solely of a homogeneous pulverized substance. The tubules are the broken fragments of the Characeestems; the two types must either have belonged to the same plants viz. as thicker or thinner stems or as branches) or to plants belonging to two different sub-families: *Chareæ*, (the stem covered with cortical cells) or *Nitelleæ* (the cortical cells wanting see fig. pag. 60); the *Nitelleæ* have probably played an essential part in the formation of the lime. The excellent preservation of the tubules is owing to the circumstance, that the *Characeæ* not only precipitate the lime on the outer side of the stems and branches, but probably also fix it between the cortical cells and the central cell and between the cortical cells respectively. The lime percentage of the Characee-lime was 88.50 $^0/_0$; according to KOHL the p. c. of lime in the *Characeæ* can amount to 95.96 $^0/_0$. That the lime deposits in Hingesø have been built up by the agency of the *Characeæ* is sufficiently demonstrated by the superabundance of tubules and the homogenity of the material.

The origin of the Characee-lime must be traced to an earlier period in the history of the lake, when the depth was considerably greater and the water colder. The Characeæ-growths of those days have now disappeared and been surplanted by a vegetation consisting of other plants, such as *Potomogeton, Myriophyllum* a. o., now producing the mud-deposits overlying the lime. At the present day several of our lakes are at the stage, at which deposits of Characee-lime are still in the course of formation. This will especially occur in the larger bays of lakes, where the depth is from 3—5 m. The bottom soil will here often be seen covered with luxurient Characee-carpets *(Tolypellopsis)* and underneath the broken refuse of the vegetation in the shape of the lime tubules corresponding with the above mentioned fossil tubules. In peat-bogs abounding in *Characeæ* no deposits of this kind occur, the dead plants and broken remnants here passing into a noxious, sluggish mud the solution of the lime being probably due to the humic acids.

Page 62 the præhistory of the Characeæ is briefly mentioned, as well as corresponding finds reported in literature. Mounds of Characee-lime of a similar character as those reported by Forel occurring in Lac de Joux, are also met with in our lakes. The Characee-lime in Hingesø is dug out of the lake by means of machinery and made use of for agricultural purposes. It may here be worth mentioning, that at the present day the Characeæ growing in the Bodensee are fished out of the lake and spread on the fields as manure. (Migula). In our lakes the *Characeæ* do not range beyond c. 8—9 m.; of other plants only *Fontinalis* and *Elodea* occur so far out, but at this depth the Characeæ evidently have the upper hand. The formation of Characee-lime will take place at a somewhat late period in the history of the lake, viz. when the maximal depth does not exceed 10 m. and the lake bottom is a comparatively level plain over which the Characee-growths can spread.

The Mollusk-lime.

The exploration of the Danish lake bottoms have proved, that the mollusk shells do not occur uniformly all over the bottom surface. With the exception of *Pisidium*-shells they are rarely met with outside the 15 m. curve. The great majority of shells accumulate in a belt situated between the 8 and 11 m. curve. I have termed this belt the shell-zone.

Origin of the shell-zone. — The extensive accumulation of shells within the above limits owe their origin to the local deposition of the shells of mollusks living in the shell-zone. Among these *Unio* and *Anodonta* occur in considerable numbers, *Valvata* and *Bithynia*, especially *Neritina*, more rarely; probably neither of these range beyond the outer limits of the Characee-zone. The other mollusks: *Planorbis*, *Paludina*, *Limnæa* and *Neritina* are rarely or never found as live specimens at this depth in Danish lakes, all inhabiting more shallow water.

As in the shell-zone only the shells of the former occur, on the latter at any rate but exceptionally, it will be apparent, that the molluscan fauna of the more shallow waters only in a very slight degree have contributed to the formation of the shell-zone.

The outer limitation of the shell-zone may be accounted for as a natural sequence of the fact, that the mollusks of our lakes do not extend greatly beyond the 11 m. curve; only the *Pisidium* occur at the greatest depths; *Anodonta* I have taken exceptionally at 13 m. Where the molluscan life stops, the deposition of shells must also stop; at this depth no wind or wave action will be strong enough to carry the shells away from their original place of deposit. — The inner limitation of the shell-zone results from the fact, that the majority of shells in the vegetation-zone on account of the more vigorous action of chemical and mechanical agencies (surf, coarser sediment etc.) will be pulverized and dissolved, and but rarely in a recognisable shape be transported out to the deeper parts of the lake bottom.

The mollusk fauna of the vegetation-zone partly comprises the same species as the shell-zone, partly species only inhabiting the shallow waters of the shore. Among the former *Unio* and *Anodonta* occur at a depth of c. $^1/_2$ m.; the *Valvata* occur most abundantly outside 2—3 m. The *Bithynia* are spread throughout the zone, greater part however live nearer the coastline than the *Valvata*. Among the latter *Neritina* increase in numbers towards land; in summer at any rate they principally occur within the depth of one m. The most prevailing species in the vegetation-zone however are those of *Limnæa* and *Planorbis*. Among these the larger species of *Planorbis*, *L. palustris* and *truncatula* rarely extend outside the peaty bays. *Limnæa stagnalis* was not met with beyond 5 m. *Limnæa ovata* and *auricularia* rarely outside 6—7 m. p. 74—75 I have compiled what is known at present as to the bathymetrical distribution of the Mollusks of European lakes.

Among other works SURBECK's explorations of the Vierwaldstädter See should here be specially noted. The results he has arrived at harmonise well with my own.

In the vegetation-zone the mollusk shells deposited outside the 2—3 m. curve are subjected to a strong chemical corrosion, and are often, contrary to those of the shell-zone, worn very thin (recorded by A. C. JOHANSEN); shells deposited nearer the coastline will after being pulverized into a whitish powder in the surf (milky water) be carried out into deeper water. This particularly applies to shells of *Planorbis*, *Limnæa* and *Neritina*, partly to *Bithynia* and in a slight degree to the shells of mussels. The accumulation and pulverization of shells principally takes place in spring. At this season a general dying out of old snails recurs. At a certain stage of putrifaction the softer parts protrude from out the shells and are converted into balls of jelly, which in the month of April may be seen bordering the beach of the Furesø.

As the molluscan life of our lakes the Pisidium excepted does not extend beyond 11 m. and the shells of the vegetation-zone in a great measure are dissolved or pulverized by the intense action of the various erosive agents of this zone, the mollusks of the intermidiate shell-zone represent a strictly local shell depositing factor by whose agency the mollusk banks are formed. In the more tranquil waters out at this depth, beyond the limits of the vegetation-zone and its copious deposits of organic matter an accumulation of shells can take place without being disturbed by the dissolving and grinding factors of the shallow waters. Explorations show, that in two of our lakes, between the 8—11 m. curve, a series of banks occur consisting chiefly of mollusk shells imbedded in a bluish-grey lake-lime. I consider these banks to owe their origin to the agency of the mollusks. As to this point explorations of larger lakes would be desirable. Often the accumulation of shells in this zone is immense; seemingly there is a striking disproportion between the enormous amount of empty shells and the relatively few specimens of live mollusks; yet it must be remembered, that vast accumulations of shells may as well result from a slow process of deposition during a long space of time as from a more active deposition of a shorter period. Where the soil conditions are suitable, the shells gradually pass into the above mentioned soft and pliable substance, from which the special kind of lake-lime I have termed Mollusk-lime originates. In such sections of the shell-zone where organic matter is predominant in the bottom soil, and the colour of the same is black instead of greyish blue, no lime-deposits will occur and no banks be forming. To elucidate this, the lime percentage of bottom samples from different parts of the shell-zone containing immense quantities of shells imbedded in black mud of a nauseous smell, was determined. These samples from two of our larger lakes respectively contained 0.4 $^0/_0$ and 0 $^0/_0$ $CaCo_3$. The lime, I suppose, has here been dissolved by the acids resulting from organic decay, and the lime-deposits consequently have been precluded.

In the history of the lake the shell-zone will not always be stationary; according as the lake is being silted up, the outer limits of the shell-zone will be extended and removed farther out from the original coast-line. When the maximal depth of the lake has been reduced to 14—11 m. the mollusks will occupy the entire bottom of the lake, and being scattered all over the same, the formation of a shell-zone will be out of the question.

Kap. II. Limonite in the shape of pea-ore (Bohnerz).

In the summer 1897 the author came across considerable quantities of pea-ore (Bohnerz) in Furesø. A close examination of this substance, which has hitherto not been met with in this country, showed, that the pea-ore found in the above lake mainly originates from a metamorphose of mollusk shells, chiefly *Valvata*, see plate II fig. 10—29 and that the phenomenon is only met with in the shell-zone. My above mentioned explorations in the summer 1900 only brought to light small quantities of pea-ore in the lakes under observation, and in none to the same extent as in Furesø. The samples all originally proved to have been mollusk shells, and were not found outside the shell-zone. In Tjustrupsø the limonite chiefly proved to be metamorphosed mussel shells, of which the scraper brought up some specimens in an unimpaired state, some in a state of transition, and others in which the transformation into limonite was complete, see tab. I fig. 36—41. A close study of this transition from shell into pea-ore makes it possible to follow the process of transformation step by step: first the iron coatings upon the cuticula will form, next the cuticula itself becomes imbued; in older shells the prismatic layer assumes a brown colour, whilst the structure still remains distinguishable; in very old shells the nacreous layer and all has been converted into limonite, and the metamorphose is complete; that those unshapely lumps of iron have once been mussels, will not readily occur to the observer. — Iron coatings occur even on the shells of living animals. In how far limonite must be traced to the agency of the bacteria, the author must leave an open question; p. 80 the opinions of WINOGRADSKY and MOLISCH on this point have been set forth.

Kap. III. Gytje and nearly assosiated formations.

With regard to our Danish lakes it was to be expected, that considerable clay and lime-deposits might still be in the course of formation in the upper layers of the deep lake bottoms;

this however proves not to be the case. The formation of pure lake-clay and lake-blege, originating from particles of clay and lime dropping down through the water and settling at the bottom, presumably belongs to a bygone time, when the lakes were colder and deeper, the vegetation-zone narrower and the deposition of organic matter inconsiderable.

The erosive power of the streams being at the time immidiately succeeding the glacial period more active than at present, vast quantities of clay and lime would in an unmixed state be deposited upon the bottom of the lake.

At the present time the organic admixture is so copious, that at any rate the upper layer of the bottom soil does not present deposits either of pure clay or pure lime; the term gytje may then be used as a general denomination for this upper layer in our larger lakes. The word gytje is introduced scientifically by v. POST in his admirable work: »Studier öfver Nutidens koprogena Jordbildningar« (Kungl. Svenska Vetenskaps-Akademiens Handl. 1860), which it must be regretted has not attracted deserved attention abroad. By gytje v. POST understands such deposits as arise in clear and limpid water, and principally consist of the excrements of animal organisms.

I opine that gytje is always a surface layer; the bacteria working in deeper strata of the bottom soil than the fauna, extort the remains of organic matter from the excrements of the fauna, and if the process be allowed to proceed undisturbed, only the mineral compounds will be left. Yet in our comparatively shallow lakes the process is liable to interruption before it is carried through. On comparing the colour of the excrements of the fauna with the colour of the upper layer of the lake bottom I observed, that the excrements are of a lighter shade than the bottom; this is probably owing to the fact, that the animals, having exhausted the organic matter, only let the inorganic matter pass through their digestive tubes; the lighter colour of the gytje is consequently due to excremental processes.

By this digestive agency of the fauna and the bacteria I conclude that the lake-clay and lake-blege may still be forming; the main difference between those recent coprogen clay- and lime-layers and the earlier layers of glacial lime and clay will probably prove to be, that the former are more rich in organic matter than the latter; their origin however is altogether different.

The main condition for the formation of gytje appears to be, that no greater quantities of organic matter are precipitated than the bottom fauna and the bacteria jointly are able to digest. If the supply of organic matter becomes more copious, black, fetid mudformations of a different character will arise (deposits in river-deltas, in many ponds, common sewers etc.).

Where the organic matter, owing to the humic acids of the water is preserved, peat will arise. The proper balance between production and consumption is most easily brought about in pure limpid waters, where according to v. Post and G. Andersson the formation of gytje consequently will take place.

According to the different local conditions, different types will occur; v. Post mentions: paper-gytje (Ehrenberg's, Wiesenpapier), spring-gytje, pond-gytje, river-gytje and shore-gytje. In my opinion this is comprising to many subdivisions under the head of gytje; I only apply the term to those particular mudformations of coprogen nature, which occur at the bottom of pure, limpid waters and which commonly contain a considerable amount of clay and lime (20, 30 %), and only a slight amount of indigested material. The above mentioned pond-gytje and probably also paper-gytje must then be excluded.

As to the lakes v. Post distinguishes between two kinds of gytje, lake-gytje from the deeper parts of the lake and shore-gytje; the latter is found in the littoral zone, and mainly results from an accumulation of débris of beach- and shore-vegetation and the excrements of snails. The boundary line between the two types according to v. Post should be drawn at the depth of 3—4 m. I agree with v. Post, in as much as I am of opinion, that those two types of gytje must be maintained also with regard to our lakes, only the line should be moved further out, either to the outer limits of the vegetation-zone or to those of the shell-zone as respectively indicating the nearer and the remoter limits of the copious deposits of shore-vegetation, outside of which the deep bottom fauna, *Oligochæta, Pisidium, Ostracoda* and *Chironomus*-larvæ prevail; as v. Post's exploration only extend to the 5 m. curve, the shell-zone was not known to him.

Of deposits rich in inorganic matter inside the 11 m. curve lake-marl, Characee- and Mollusk-lime have already been mentioned. A more minute study of the chiefly organic deposits occurring inside this curve, f. ex. shore-gytje, is so closely connected with the study of the shore-vegetation as not to be pursued separately. Investigations upon this point being in progress by others, I have not studied these formations. Further researches will undoubtedly show, that several of the formations now termed lake-marl will be closely allied to shore-gytje.

Lake-gytje differs from other gytje deposits as being in most cases largely composed of the débris of plankton organisms, chiefly a few easily definable plankton Diatoms — *Stefano-*

discus Niagaræ, *Melosira crenulata* and *granulata*, and very often *Asterionella gracillima* — which may be considered as index fossils; in all probability lake-gytje is richer in inorganic matter than most of the other types of gytje.

The gytjes of our lakes often vary considerably as to character; nevertheless the fixing of distinct types becomes difficult on account of the numerous intermediate forms.

I premise, that lake-gytje of course can not be sharply defined from lake-blege and lake-clay. In the Danish paper pag. 93 I have mentioned the lime percentage in the bottom-soil of our larger lakes which is often very high (20—60 $^0/_0$); as I have proposed to use the name lake-blege only for deposits with a lime percentage exceeding 80 $^0/_0$ this word will not apply to the former; gytjes copiously charged with lime I have termed lime-gytje (Kalkgytje). We shall here however only discuss the organic components of the gytje.

The origin of the organic matter of the lake-gytje must be traced partly to the plankton, partly to the flora and fauna of the adjacent country and partly to the littoral zone of the lake. Greater part of the material contributed by the above agencies only reaches the bottom in a pulverized state. By plankton investigators this organic »rain« is often termed »dirt«. The amount of it might possibly be determined by means of a plankton pump, which has however not been at my disposal.

In the pursuit of plankton studies¹), carried on contemporately with the exploration of the above mentioned lake bottoms, I arrived at some results which I think may influence a more minute study of the lake bottoms; I have thence tried to subdivide the lake-gytje into different types, which I think may be maintained, notwithstanding the difficulty of classifying those mudformations.

As to the origin of gytje sufficient attention has hitherto not been paid to plankton; in studying the gytje of a lake it is first of all necessary to ascertain the character of its plankton; this varies considerably in the different lakes and even in the same lake at different periods; in accordance with this fact the chemical composition of the dead plankton precipitated upon the bottom surface varies greatly as well with regard to time as to locality. A closer study of the chemical nature of the plankton is especially necessary in relation to gytje.

As we are only able at present to determine the cellular contents of the plankton organisms as albumen and water, and as we have no knowledge of the manner in which the albumen is dissolved upon the lake bottom, we must chiefly restrict our-

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¹) which will be published in a subsequent paper.

selves to discuss the chemical composition of the skeletons of the plankton organisms and their bearings upon the formation of lake-gytje. As my own plankton observations prove, that in deeper lakes dead plankton is only deposited in the shape of empty skeletons, I consider this limitation warrantable. With FOREL I take it for granted, that while the organisms are sinking down through the water, the soft parts are consumed by the bacteria; I have found this dead plankton consisting of empty skeletons suspended in deep water in several of our larger lakes. In shallow lakes (3—4 m.) the bottom is often covered with a whitish grey, putrified, fetid layer, consisting of plankton organisms, which have not been consumed during their shorter downward passage, so that the process of decay of the cellular contents here is continued after sedimentation.

The skeletons of plankton organisms consist either of silica, chitine, cutine, cellulose or calcium carbonate; the latter is only skeleton forming in the small number of plankton *Rhizopoda;* it has been pointed out in the shells of *Peridinea* (by SHILLING), and will in all probability be found in small quantities in the chitinous skins of plankton Crustacea. The amount of calcium carbonate, which plankton yields to lake-gytje is however insignificant. Plankton deposits corresponding to the Globigerina deposits of the ocean probably never occur in fresh water basins.

The skeletons of Diatoms are composed of silicic acid; the skins of Crustacea and Rotifera of chitine, probably also the coatings of *Codonella lacustris* and *Dinobryum.* The skeletons of Peridinea consist of cellulose, among these especially *Ceratium hirudinella* is an important agent in the formation of plankton. Closer examinations as to the chemical nature of the cell walls of the *Chlorophyceæ* being to my knowledge as yet wanting, we must for the present also class the cellular walls of these as belonging to cellulose; among the numerous *Chlorophyceæ* only *Pediastrum* is of special importance in relation to plankton and gytje. A substance allied to cutine is said to form the cell walls of the Cyanophyceæ, of which several play an essential part in this respect.

My above mentioned plankton investigations show, that in every one of our lakes only a few species of plankton organisms, differing in the various lakes reach the enormous maxima well-known to all plankton investigators; the chemical composition of the gytje of a lake will therefore principally depend on the chemical nature of the skeletons of these particular organisms.

The plankton investigations have further proved, that the chitine-producing organisms form the essential part of the plankton, especially in shallow lakes, and that our deeper and larger lakes almost never afford equally favourable conditions to both of the two principal plankton forming groups the Diatomeæ, producing silicid acid, and the cutine producing Cyanophyceæ.

In accordance with these results gathered from the plankton investigations we are now able to point out three different kinds of lake-gytje.

In lakes with high Diatomee-maxima the lake gytje contains vast quantities of shells of plankton Diatoms and is termed Diatomee-gytje.

In lakes with high maxima of chitine producing organisms a greyish brown faintly malodorous mud is deposited: chitine-gytje.

In lakes with high Cyanophycee-maxima the gytje will consist of a bluish black, fetid, exceedingly fine mud: Cyanophycee-gytje.

A special kind of lake-gytje arising from deposited cellulose does not occur, as this substance is quickly dissolved and disappears in the gytje.

Owing to the fact, that plankton always contains both some silica-, chitine- and cutine-producing organisms, it must however be emphasized that gytjes of a mixed character often, strictly speaking always will arise; even if one of these groups, say the silica producing, be by far the most predominant, the other groups may yet be represented to an extent, that will influence the general character of the gytje.

Many other conditions contributing to modify and transform the gytje, which according to the nature of the plankton should be typical for the lake in question, may further give rise to gytjes of a mixed character. In the first place the proportions of zoo-plankton and phyto-plankton of a lake, do not correspond with the amount of the respective skeleton-débris in the gytje. Zoo-plankton generally stands deeper in the water than phyto-plankton and is less liable to be caught by the waves or carried away by the outlets; part of the latter, especially the *Cyanophyceæ*, is either deposited as mud near the shore or carried away by the outlets, whereas the zoo-plankton is principally deposited in the deeper parts of the lake bottom. Secondly: the process, which the sedimented material is subjected to in the digestive tubes of the bottom fauna, does not affect the skeletons in the same manner and to the same degree; the cellulose is in all probability quickly dissolved; the chitinous skins get pulverized, but the Diatomee shells will, with the exception of the somewhat jagged edges, pass the digestive tubes almost unimpaired; examinations of the excrements of the *Chironomus* larvæ confirm this. Thirdly: streams receiving tributaries from other water basins will carry plankton from the latter into the next lake, and will deposit it along with the perhaps, greatly differing local plankton of this lake. Fourthly: the incongruity of the plankton and the lake-gytje may be due to the fact, that the various skeletons also apart from the consequences of the digestive processes are not preserved for an equal length of time in the lake bottom. Cellulose probably quickly dissolves into marsh-gas (CH_4), and carbonic acid (CO_2). Six months after an enormous maximum of *Ceratium hirudinella* had been noted in one of our lakes, I was not even able to make out their skeletons in the gytje of the lake. Also the cell walls of *Cyanophycea* disappear completly; of the chitinous skeletons the thinnest likewise seem to disappear (*Rotifera* and *Dinobryum*); occasionally I have met with dead Rotifer-plankton, consisting of partly dissolved chitinous skins; skeletons of *Copepoda* also seem to vanish quickly, or at least to become undistinguishable; best preserved are the coats of *Codonella lacustris*, and the skins of the *Daphnidæ*, among which the wellknown antennæ and valvæ of *Bosmina* are conspicuous. The *Diatoms* will keep longer than any of the other organisms and are important agents in the formation of lake-gytje. The Diatomee-shells are principally due to the plankton Diatoms, and only in a very slight degree to the fixed shore Diatoms; the shells of the latter decrease in numbers towards the deeper parts of the lake, and are here due to the Diatomee coatings of submerged aquatic plants, which in autumn are carried outward, and from which the coatings drop off. Examinations prove, that a special Diatomee flora peculiar to the deeper parts of the lake bottom cannot be pointed out. The brown colour of the cromatophors does not prove, that the forms actually belong to and live in the deeper localities, seeing that this colour according to KIRCHNERS and to my own observations will keep for three months. The various Diatoms are preserved differently and for an unequal length of time. I have never found the thin shells of *Atheya* or *Rhizosolenia; Melosira, Cymatopleura elliptica, Stephanodiscus Niagaræ* often occur in enormous quantities; asteriated Diatoms *(Asterionella, Tabellaria)* are deposited as single individuals.

Notwithstanding the above mentioned special conditions, which may cause incongruities between the gytje of a lake and its plankton, and by means of which the gytjes of a mixed nature may arise, the three above mentioned main types for lake-gytje, Diatomee-, Cyanophycee- and Chitine-gytje are often represented in the Danish lakes (see tab. 3 and discription). The fact is that the *Diatomeæ* reach their maxima in deep, cold lakes, the *Cyanophyceæ* in shallow, warm lakes, and as the Danish lakes are only exceptionally deep and cold, we have but few lakes with high Diatomee-maxima and corresponding lake-gytjes, whereas many lakes show high Cyanophycee-maxima and pronounced Cyanophycee-gytjes; on account of the durability of the Diatomee-shells, these will accumalate in vast quantities in lakes, that excel in Diatoms.

The most typical Diatomee-gytje was found in Haldsö (tp. of bottom sample 28th July 1900 + 6½° C.). Just taken out of the water it is perfectly black and contains vast quantities of plankton Diatoms, chiefly *Stephonodiscus Niagaræ,* and *Melosira granulata* (tab. 3) deposited in an almost impalpable black mud, probably consisting of cromatofors seceded from deposited shells. Diatomee deposits of this discription from deeper lake bottoms have to my knowledge not been found before; shallow water deposits chiefly made up of shore Diatoms are known from REUSCH and TRYBOMS statements.

According to FOREL and KIRCHNER the Diatoms in the deep lake bottoms of Genfer- and Bodensee (2 – 300 m.) are only of slight importance, and the few individuals principally reported as bottom Diatoms.

As the works treating on the plankton of those lakes show, that Diatoms play a prominent part in the same, the question arises, why the shells in the Diatomee-plankton of Bodensee and Genfersee are dissolved and disappear, whilst the shells accumulate upon the bottom of Danish lakes. The vast difference in depth between our deepest lakes, 40 m., and that of the Swiss lakes may account for the fact, that the shells on their descent through the 7—8 times deeper body of water are dissolved before reaching the bottom, whereas in our shallow lakes no such solution takes place. Whether in the course of time a slow dissolution of the deposited shells does take place and renders them unconspicuous in the deeper layers, must at present remain undecided.

In exploring the Silkeborg lakes my attention was called to the fact, that the plankton of the latter, at the point where Salten River enters Guden River, all at once changes character. Up to this point the plankton had been chiefly charactarised by *Diatoms;* beyond the conflux of the two streams by *Cyanophyceæ,* principally *Aphanizomenon,* in enormous quantities ushered into Guden River through Salten River. In accordance with the above, Diatomee-gytje and Diatomee-clay was found in the lakes up to the entrance of Salten River, the Cyanophycee-gytje only beyond this point.

Besides the above mentioned three types of lake-gytje, and the compound gytjes arising from intermixture of their components, a more copious addition of inorganic matter in this country chiefly clay and lime, will give rise to further compound gytjes. Among these *Cyanophycee-clay*, *Diatomee-clay* and *Diatomee-lime* are most prominent. For the bottom proofs of our larger lakes the following terminology may be established.

chiefly organic matter	Cyanophycee-gytje Diatomee-gytje Chitine-gytje
mixture of organic and inorganic matter	Cyanophycee-clay Diatomee-lime Diatomee-clay
chiefly inorganic matter	lake-clay, lake-blege (Søblege).

If sufficiently deepgoing bottom proofs could be obtained, the consecutive order of these formations would in all probability recur in the bottom proofs, so that we should expect to meet with:

Cyanophycee-gytje,	Diatomee-gytje,	Diatomee-gytje,
— clay,	— clay,	— lime,
coprogen lake-clay,	coprogen lake-clay,	coprogen lake-blege,

With regard to the bottom fauna I shall here only observe, that in all essentials it is of the same character as the deep-lake fauna recorded by Forel and others. To enter more closely upon this subject would be purposeless, until investigations (on other hands) now in process have been published.

As to the bearings of the fauna in relation to the bottom soil they are of a double character: first, as hightening the lake bottom and adding to the elementary constituents of gytje; secondly, as converting those constituents into excrements.

From the various plankton explorations it must be inferred, that plankton skeletons of entirely different character are precipitated at the different seasons of the year: in early summer chiefly silicid acid, originating from Diatoms; in autumn cutine from Cyanophyceæ. Owing to the fact, that maxima of plankton organisms always occur coincidently with certain temperature optima, year by year recurring at the same time, we might expect to find the lake-gytje stratified and exhibiting distinguishable differences in the chemical nature of the respective layers; however neither recent nor subfossil gytjes confirm such a supposition; to my opinion the original stratification is effaced and lost by the rooting and excrementing agency of the bottom fauna.

It has already been mentioned, that the organic matter by the joint action of the fauna and bacteria gradually disappears, so that at a certain depth only an inorganic remainder will be left. Even by means of the dredge three layers may be distinguished, an upper layer of a deep brown colour, as yet but slightly influenced by the bottom fauna, and in character somewhat differing from »*le feutre organique*« reported by **Forel**; owing to the soft almost fluid condition of the bottom mud, I have never met with any typical bottom surface, corresponding with »*le feutre organique*« or with **Brands**: »Grundalgenzone« — beneath this top layer is a yellowish fetid layer, inhabited by numerous organisms, chiefly bacteria, and underlying this the bluish grey layer thorougly excremented and rich in inorganic matter; this layer will gradually blend with the subjacent coprogenous lake-clay or lake-blege which probably rests upon the pure glacial deposits of clay or lime.

POSTSCRIPT.

Shortly after delivering a discourse in the geological society of Copenhagen (12 Dec. 1900) on the origin and formation of lake-lime, in which discourse the occurrance of a considerable amount of Characee-lime in one of the Danish lakes was specially brought forward, this substance not having been found in any of our lakes before, my attention was called to the fact, that two essays by C. A. **Davis** had been published in Journal of Geology Vol. VIII Sep.—Oct. 1900 under the heads: A contribution to the natural history of marl (p. 485—497) and: A remarkable marl lake (p. 498—503).

It appeared, that **Davis** had particularly made the Characee-lime his study. In several points our observations seem entirely to concur, and in others in some measure to supplement each other. As I was not able at the time I had read Ds.' interesting essays to make any mention of them in my manuscript, which was just going into the press, I preferred in a postscript to add an abstract of the same, his explorations being so closely allied to my own, and as it appears, carried on contemporaneously. I have thought fit mainly to use his own words.

According to **Davis** the marl deposits, with the exception of the vegetable matter, owe their origin to the clays of glacial deposits and like disintegrated rock-masses. Percolating water containing dissolved carbon dioxide dissolves the calcium; the water with the dissolved matter runs along underground until an outlet is reached and then issues in the form of a spring. This in turn uniting with other springs forms a stream, which runs into a lake, carrying along with it the greater part of its mineral load. If the amount of carbon dioxide contained in the water is considerable, some of it will escape on reaching the surface because of decrease of pressure, and with its escape, if the saturation point for the dissolved mineral matter has been reached, a part of this matter must be dropped in the form of a fine powder, as the water runs along over the surface. From this point of view it might be expected, that the waters of these springs and streams would show more or less milkiness; as this however is not the case, D. concludes, that there is not a large amount of calcium dioxide and no approach to the saturation point for calcium bicarbonate in the springs and streams feeding marly lakes. — In this manner then D. is of opinion that marl does not originate.

We are, then, according to D. left, among others, the following alternatives, explanatory of marl formation:

1. The marl is not being formed under existing conditions but at some previous time. 2. The marl is formed not in the springs but exclusively in the lakes, and in consequence of slow evaporation and the reduction of the amount of dissolved carbon dioxide in the water, which brings about deposition of the mineral salts. 3. Some other cause, or causes, than the simple release from the water of the solvent carbon dixoide must then be sought.

D. of course at once rejects the first of the three explanations and also concludes, that the marl no more originates in the manner mentioned in 2. He rests his opinion partly upon the circumstance, that the water of lakes with swift flowing and extensive outlets, such as most of the marly lakes explored by him have, is changed so rapidly that little if any concentration of a given volume of water would occur while it was in the lake, partly upon preliminary investigations which show, that the volume of water flowing out of these lakes is practically the same as that flowing into them. Further D. founds his opinion upon the explorations of Treadwell and Reuter.

In accordance with the Swiss investigators I think, that D. has somewhat underrated the importance of the directly from the water, by the reduction of the amount of dissolved carbon dioxide precipitated calcium carbonate in the formation of lake-lime.

D. then arives at the conclusion, that, the marl originates from the agency of organisms; among these the mollusks and the plants are mentioned. In the localities which D. has explored he considers the former as being only of small importance; as regards our country the conclusions I have arrived at in this respect do not concur with those of D. He then comes to the conclusion, that the plants play the most prominent part as precipitating agents for the calcium salts. The precipitation of lime upon the plants is according to D. owing to one of the two following causes: If the calcium and other salts are in excess in the water, and are held in solution by carbon dioxide, the more or less complete abstraction of the gas from the water in direct contact with plants, causes precipitation of the salts upon the parts abstracting the gas, namely, stems and leaves. But in water containing amounts of the salts, especially of the calcium bicarbonate, so small that they would not be precipitated if there were no carbon dioxide present in the water at all, the precipitation may be considered a purely chemical problem, a solution of which may be looked for in the action upon the bicarbonates, of the oxygen set free by the plants.

In accordance with the fact, that not even all species of the same genera, even when growing side by side, will be coated equally, D. further supposes the presence of some selective metabolic processes as yet not understood. He emphazises, that the lime crusts are purely external which as regards the Characeæ will scarcely hold good (Kohl). Among the lime producing plants the higher plants the Characeæ and the blue-green algæ are particularly mentioned. Principally owing to the fact, that in early spring or late fall, all plants of the higher types will not be found, D. concludes, that the agency of these plants is merely a seasonable one, and that such work as these plants are doing, is but a small factor in the total sedimentation of the lake. Herein I agree with D.

Professor D. further concludes, that the Characeæ play an important part in the formation of the marl; several of the recorded observations coincide with my own. The Characee material has been analysed by D.; upon this point I refer to his own paper. D. points out a fact which did not come under my observation, that marl beds of several, and even as much as twenty or more feet in thickness will »run out« abruptly into beds of »muck«, or pure vegetable débris, of equal thickness. In this connexion D. remarks, that this distribution may show, that up to a certain time conditions unfavorable to the growth of Chara are favorable to other plants obtained, until a depth of water was reached at which Chara was able to occupy the bed of muck. From the time when the Chara began its occupation of the muck the amount of organic matter left would decrease, and the amount of calcareous deposits would increase, until the latter predominated.

The stone covering blue-green algæ seem to be unknown to D.; but he mentions certain not precisely determinated blue-green lime incrusted algæ which grow in colonies, and precipitate the calcium carbonate; these algæ at first are affixed to mussels etc. but subsequently detatch themselves forming pebbles of greater or lesser size. These algal calcareous pebbles show both radial and concentric structure and might well be taken for concretions formed by rolling some sticky substance over and over in the wet marl, on which they occur. Included within the structure of the pebbles are great numbers of plants, besides the calcareous blue-green algæ among the considerable numbers of Diatoms. It is possible to recognise the pebbles, as lumps of coarser matter, even in very old marl; they are found in four typical marl lakes, and have been reported from a number of others by marl hunters. From these facts D. concludes, that they are constant if not important contributors to marl beds. To my knowledge corresponding formations have not as yet been found in Europe.

In the second paper: »A remarkable marl lake« Professor D. has mentioned the deposits of marl in Littlefield lake, Isabella County, Michigan one and one half miles long, by three fourths of a mile broad; in the widest part it was said to be eighty feet deep; in the lake there are three small islands; the entire shore of the lake is formed by beautifully white marl, the exposures varying in width from a few feet to three or four rods in width, so that as one overlooks the lake from one of the surrounding hills, it seems to lie in a basin of white marble. The bottom of the lake and its deposits have not been explored; the marl deposits on the beach are frequently thirty feet deep; the color is yellowish or creamy, or, it is almost purely white. At the surface the marl is coarser, slightly yellowish and more compact. On the parts of the shores where apparently the wave action is chiefly exerted, there are small rounded calcareous pebbles, mixed with molluscan shells, drift material, and considerable quantities of stems, branches, and more or less broken fragments of Characee stems, all parts of which are heavily incrusted with calcareous matter. This Chara material was often piled up in windrows of considerable extent at the high-water mark. From this wind and wave accumulated material the marl deposits arise. Corresponding shore-deposits of partly pulverised Characeæ may also, but in a very inferior degree be observed along the shores of Danish lakes. The above mentioned three islands likewise consist of marl from twenty five to thirty feet deep; they evidently correspond with the islands mentioned by Forel and the submerged banks found in the Furesø.

Freshwater biological laboratory
on Furesø.
Frederiksdal pr. Lyngby.

Trykfejl, der bedes rettede.

Side 48, sidste Linie Fig. 6, læs Fig. 1—6.
- 49, Linie 9 f. o. al, læs næsten al.
- 60, i Figurforklaringen tilføjes: Forst. 60 G.
- 75, Linie 3 f. n. Tiberia. læs Tiberias.
- 99, Linie 16 f. o. Potamogetonernes, læs Potamogetoneernes.
- 122, Linie 16 f. n. vestfra, læs østfra.

Forklaring til Tavle 1.

(Explanation of plate 1.)

Fig. 1—6. *Planorbis corneus* fra en Dam nær Furesøen. Nat. St. Øverste Række viser Skaller, som den Gang, de blev fundne endnu indeholdt levende Dyr; nederste tomme Skaller optagne fra Bunden ved Sigtning af Bundslammet.

De ubeskadigede Partier paa Skallerne i første Række er dyb mørkegrønne; paa Fig. 1 ses stærk Corrosion paa de ældste Vindinger; enkelte spredte Huller over den øvrige Skal; Fig. 2 er stærkere corroderet; i Fig. 3 er Skallens yderste Lag ganske forsvundne, og flere Huller er dannede; Dyret, som omsluttedes af Skallen, var meget mat.

I Fig. 4 ses de enkelte Gruber tydeligt; Fig. 5 viser en Skal, der er nærved at falde fra hinanden, og hvor flere Huller forekommer; Fig. 6 et Skalrudiment.

(*Planorbis corneus* from a pond near Furesö; nat. size. The upper series representing shells, that, when found, still contained live animals; the lower series, empty shells obtained by sifting of the bottom-dirt.

The unimpaired parts of the shells in the first series are of a deep-green colour; the older whorls are highly corroded; the rest of the shell only shows a few stray hollows; fig. 2 is still more corroded; in fig. 3 the exterior layer has disappeared and more holes have been formed; the animal itself was very weak.

In fig. 4 the grooves are plainly seen; fig. 5 shows a shell fast decaying to pieces, and where the bottom of the grooves is often wanting; fig. 6 rudiment of a shell.)

Fig. 7. *Anodonta* (nat. St.) fra Esromsö; c. 4 M.; Bunden sort, rig paa organiske Stoffer. Skallerne omsluttede ved Optagelsen et levende Dyr. De mørktfarvede Partier er den

delvis med Alger besatte Kutikula: man ser det blottede Prismelag, Perlemoderlaget og de pag. 40 omtalte Afsatser; det mest angrebne Parti af Skallen bestaar kun af nydannede Conchyolinlameller næsten uden Kalk imellem.

(*Anodonta*, nat. size, from Esromsö; c. 4 m.; bottom black, rich in organic-matter; when brought up the shell enclosed a live animal. The dark-coloured parts show cuticula partly coated with algæ; the uncovered prismatic-layer; the nacreous-layer and the terraces mentioned pag. 40 are seen; the most corroded part of the shell consists of newly-formed conchyolin lamels, with almost no lime between.)

Fig. 8. Characeekalk fra Hingesø (nat. St.); mærk de talrige Huller, der er Tværsnit af Characeerørene.

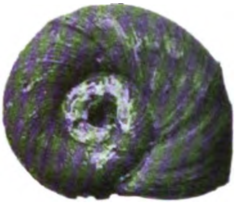
(Characee-lime from Hingesö; nat. size; the numerous holes arise from transverse breaking of the Chara-stems.)

Fig. 9. Subfossil Muslingskal (nat. St.) fra Skanderborgsø (10 M.). Bundart: stærk kalkholdig, blaagraa Sømergel. Skallen kridtagtig, blød; nederst ses en Belægning af det hensmuldrende Prismelag; iøvrigt bestaar Skalstykket af Perlemoderlaget; Kutikulaen er forsvunden.

(Sub-fossil mussel-shell, nat. size, Skanderborgsö (10 m.). Bottom-sample: bluish-grey lake-marl, shell chalky, soft; in the lower part a coating of the mouldering prismatic-layer; for the rest the shell fragment consists of the nacreous-layer; cuticula has disappeared.)

D

1



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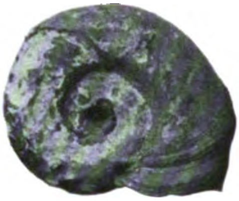

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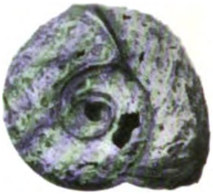

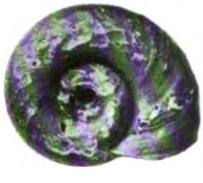

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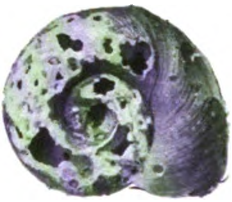

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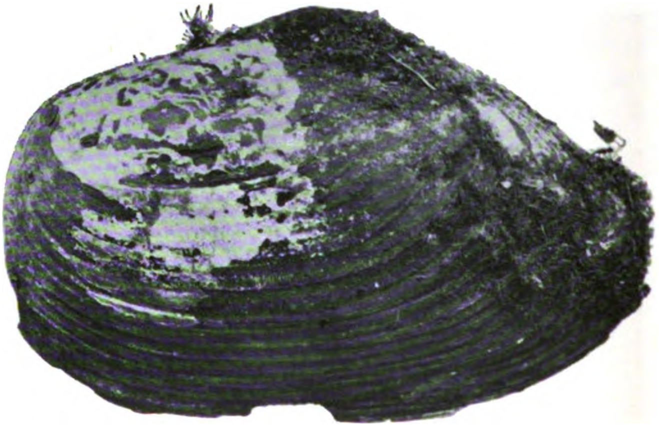

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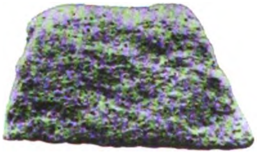

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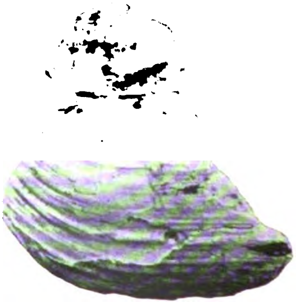

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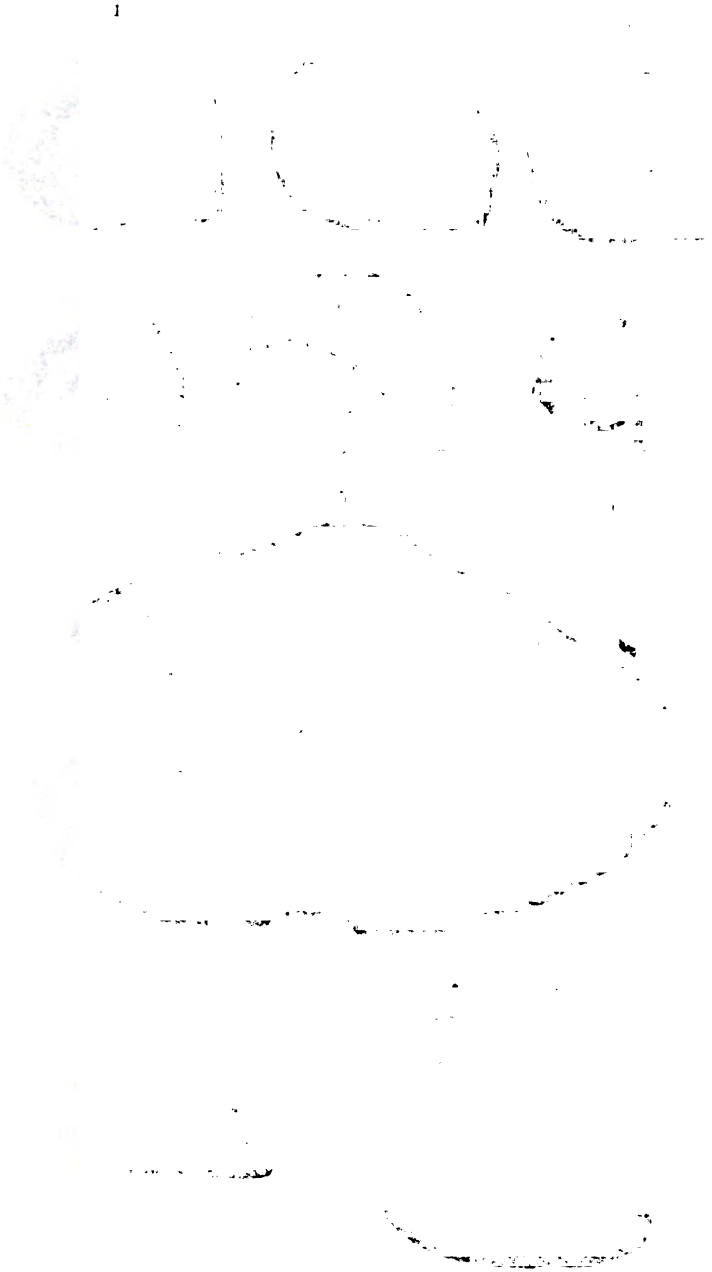

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Forklaring til Tavle 2.

(Explanation of plate 2.)

Fig. 10—29 illustrerer Snegleskallernes Omdannelse til Bønnemalm. Forst. $1^1/_2$.

Fig. 10 omdannet Skalsøjle af *Limnæa.*

Fig. 11—15 gradvis Omdannelse af *Neritina fluviatilis*, Fig. 11 viser Skallen med næsten naturlig Farve, Fig. 12—13 Skallen belagt, Fig. 14 Skallen næsten omdannet, Fig. 15 Skallen omdannet til Bønnemalm i Form af en Kaffebønne.

Fig. 16—29 gradvis Omdannelse af *Valvata piscinalis.* Fig. 16 subfossil hvid Skal med fraspræengt Kutikula; Fig. 17 svagt belagt Skal, Fig. 18 stærkere belagt, Fig. 19 Rummet mellem Skallens Vindinger stærkt udfyldte, Fig. 20 næsten totalt udfyldt. Fig. 21 tilsvarende Stykke; Skalmundingen ses, Fig. 22—26 uformelige, til Bønnemalm omdannede Klumper, delvis sønderbrudte, svagt angivende enkelte Vindinger og visende Udfyldningsmassen med sin Belægningsskorpe; Fig. 27 et typisk Stykke Bønnemalm, Fig. 28—29 do. med fraspræengt Belægningsskorpe.

(Transformation of snail-shells into pea-ore, magnified $1^1/_2$.

Fig. 10 transformed shell-column of *Limnæa.*

Fig. 11—15 gradual transforming of *Neritina fluviatilis.* Fig. 11 the shell of almost natural colour; fig. 12—13 the iron coated shell; fig. 14 the shell almost transformed; fig. 15 the shell transformed into pea-ore in the shape of a coffee-berry.

Fig. 16—29 gradual transforming of *Valvata piscinalis.* Fig. 16 subfossil, white shell, cuticula wanting; fig. 17 slightly coated shell; fig. 18 more heavily coated; fig. 19 the space between the whorls partly filled up; fig. 20 almost totally filled. Fig. 21 a similar piece; the aperture of the shell is seen; fig. 22—26 unshapely, partly broken lumps

transformed into pea-ore, faintly indicating a few whorls and showing the filling mass and its coating; fig. 27 a typical piece of pea-ore; fig. 28—29 the same with detached coating.)

Fig. 30—35 illustrerer **Muslingskallernes Omdannelse i Furesøen.** Forst. $1^1/_2$.

(Transformation of mussel-shells in Furesö; magnified $1^1/_2$.)

Fig. 36—39 illustrerer **Muslingskallernes Omdannelse i Tjustrupsø.** Størrelse $^1/_1$.

Fig. 36 et større Skalstykke visende det til Brunjærnsten omdannede Prismelag; Perlemoderlaget er omtrent urørt. Fig. 37 tyk uregelmæssig Belægningsskorpe udenpaa en Skal. Fig. 38 Parti af en Skal set i Tværsnit; yderst Belægningsskorpen, inderst Perlemoderlaget. Fig. 39 et til Jærnklump omdannet Stykke Muslingskal.

(Transformation of mussel-shells in Tjustrupsö; size $^1/_1$.

Fig. 36 a larger piece of a shell showing the prismatic layer transformed to limonite; the nacreous layer is almost unmolested; fig. 37 a thick irregular iron coating outside a shell; fig. 38 part of a shell seen in section, on the outside the iron coating, inside the nacreous layer; fig. 39 a piece of a mussel-shell transformed into an lump of iron.)

Fig. 40—41. Muslingskal fra Tjustrupsø, totalt omdannet til Brunjærnsten; Skallen er set fra højre og venstre Side. Midtpartiet mangler. Nat. St.

(Mussel-shell from Tjustrupsö perfectly transformed into limonite; the shell seen both from the right and the left side; central part wanting; nat. size.)

Forklaring til Tavle 3.

(Explanation of plate 3.)

Fig. 42—44 illustrerer de pag. 110 opstillede tre Hovedtyper paa Søgytje. Hr. Lektor C. O. Jensen har godhedsfuldt taget de tre Mikrofotografier. Fotografisk Fremstilling er valgt for at komme Naturen saa nær som mulig; hvert Billede repræsenterer vedkommende Søs Søgytje, saaledes som den præsenterer sig, naar man af Bundprøven med en Pipette tager et vilkaarlig valgt Parti op og uden yderligere Behandling direkte bringer den under Mikroskopet. Af fotografiske Hensyn er forholdsvis tynde Partier i Præparaterne valgt. Forstørrelsen, c. 80 Gange, er den samme for alle tre Billeder.

(Fig. 42—44 illustrates the three, page 110 established main types of lake-gytje. Mr. C. O. Jensen, lecturer of the Royal veterinary and agricultural College, who has kindly taken the three microphotographs, I hereby render my best thanks. Photography has been chosen in order to come as near to nature as possible; each photo represents the lake-gytje of the lake in question as seen, when a sample is taken out of the bottom-sample with a pipette and without further treatment brought beneath the microscope. Owing to photographic exigencies relatively thin parts of the slides have been chosen. The enlargement c. 80 times is the same in all three photos.)

Fig. 42. Diatomeegytje fra Haldsø. 40 M. Optaget $^{23}/_{7}$ 1900. Bundtemperatur $6^{1}/_{2}$ ° C.

De runde, cirkelformede Legemer er *Stephanodiscus Niagaræ;* Kæderne tilhører Slægten *Melosira*, der i Billedet er repræsenteret i alt Fald med to Arter: *M. crenulata* (tynde Kæder) og *M. granulata* (tykke Kæder); enkelte af disse er muligvis *M. arenaria.* Nederst i Billedet findes enkelte svagt fremtrædende Stave af *Asterionella gracillima.*

Ved Beskuelsen af Billedet bør man særlig lægge Mærke til, at alle Diatomeerne er Planktondiatomeer, og at disse langt overvejer det ubestemmelige Snavs.

Den $^{23}/_7$ bestod Plankton væsentlig af en Grønalge *Conferva sp.;* store Mængder af *Ceratium hirudinella, Diaptomus* og *Asterionella gracillima;* saavel *Melosira* som *Stephanodiscus Niagaræ* var kun sparsomt repræsenterede; ved Bunden stod intet dødt Diatomeeplankton. Af Planktonindsamlinger fra 28. Januar fremgaar det, at *Melosira*-Arterne paa dette Tidspunkt har kolossale Maksima, og af Planktonindsamlinger fra 24. Maj, at *Stephanodiscus* i Foraarstiden har næsten lige saa store.

Det er Vinterens og Foraarets Plankton, der i Fig. 42 er afbildet som Diatomeegytje.

(Diatome-gytje from Haldsö. 40 m.; brought up $^{23}/_7$ 1900. Bottom-temperature $6^1/_2$ ° C.

The round circular bodies are *Stephanodiscus Niagaræ;* the chains belong to the genus *Melosira,* which in the photo is represented at least by two species *M. crenulata* (thin chains) and *M. granulata* (thick chains); some few may perhaps be *M. arenaria.* At the lower edge of the photo are a few not very distinguishable staves of *Asterionella gracillima.*

When looking at the photo it will be noticed, that all the Diatoms are plankton Diatoms, and that they in numbers by far out-weigh the indeterminable dirt.

The $^{23}/_7$ plankton chiefly consisted of a green-alga *Conferva sp.;* great quantities of *Ceratium hirudinella, Diaptomus* and *Asterionella gracillima;* both *Melosira* and *Stephanodiscus Niagaræ* were but sparingly represented, at the bottom no dead Diatomee-plankton was found. Plankton-samples from 28 of January show, that the *Melosira* species obtain enormous maxima at this time of the year, and samples from 24 of May that *Stephanodiscus* is about as numerous in spring.

It is the plankton of winter and spring that are represented as Diatomee-gytje in fig. 42.)

Fig. 43. Cyanophyceegytje fra Julsø. 20 M. Optaget den 19. Juli 1900. Bundtemperatur + 12 ° C.

Hovedmassen bestaar af mer eller mindre sammenflydende Klatter af opløste Cyanophyceer, særlig *Aphanizomenon.* Ved stærk Forstørrelse lader Geleestrukturen sig endnu paavise i nogle af disse. Spredt i Billedet findes adskillige Diatomeer, hørende til Slægten *Melosira* (rimeligvis *M. crenulata* og *granulata*).

Den 19de Juli bestod Planktonet af uhyre Mængder af den blaagrønne Alge: *Aphanizomenon flos aquæ;* Melosirerne var næsten ikke til at paavise; i Planktonprøver fra 28de December dominerede Melosirerne og var den 27de Maj ved at blive fortrængt af *Aphanizomenon.* Det er denne Plante, der i Julsø bestemmer Søgytjens Karakter.

(Cyanophyce-gytje from Haldsö; 20 m.; 19 of July 1900; bottom-temperature + 12 ° C.

The main part consists of more or less confluent particles of *Cyanophycea* especially *Aphanizomenon.* When greatly magnified, the cell-structure may still be pointed out in some of these. Here and there in the picture are several Diatoms belonging to the genus *Melosira* (most probably *M. crenulata* and *granulata*).

The 19 of July the plankton consisted of enormous numbers of the blue-green alga: *Aphanizomenon flos aquæ;* the Melosires were scarcely to be pointed out; in plancton-samples 28 of December the Melosires predominated and were 27 of May almost being superceded by *Aphanizomenon.* It is this plant that determines the character of lake-gytje in Julsö.)

Fig. 44. Kitingytje fra Bagsværdsø. 4 M. Optaget 15. Juli 1899. Bundtemperatur + 17 ° C.

Øverst Hovedskjoldet med de karakteristiske Antenner af en Slægten *Bosmina* tilhørende Art; af de øvrige tre Kitinhude er de to længst tilhøjre liggende Hude Skaldele (Valver) af Bosminer; den nærmest i Midten liggende Hud tilhører en Bunddaphnie, rimeligvis *Chydorus* eller *Alona.* I Pladens højre Halvdel 3 »Stjærner«: *Pediastrum*, sandsynligvis *P. boryanum.* I Midten en i sine Rande noget opløst, men fra Formens Side typisk Ekskrementbolle af *Chironomus.* Resten ubestemmelig. Dybest i Præparatet ligger talrige, yderst smaa Rester af Bund-Diatomeer og Chlorofyceer, særlig *Pediastrum* og *Scenedesmus.* Da det var umuligt at faa disse lagt i samme Plan som Chitinhudene, og da Indstillingen maatte rette sig efter disse sidstnævnte, kunde Diatomeeresterne ikke komme med i Billedet.

Plankton bestod den 15de Juli af uhyre Mængder af Bosminer, Daphnier og Copepoder; Planktondiatomeer manglede ganske. Da Bagsværdsø ikke er indgaaet som Led i Planktonundersøgelserne, haves ingen regelmæssige Iagttagelser fra denne Sø; dog vides det af Indsamlinger i April og i Januar, at Diatomeerne næsten mangler i Søen og af forskellige Indsamlinger i Sommerhalvaaret, at Krustaceerne i dette Tidsrum danner kolossale Maksima.

(Kitin-gytje from Bagsværdsö; 4 m.; 15 of July 1899; bottom-temperature + 17 ° C.

Uppermost the carapax, with the characteristic antennæ, of a species belonging to the genus *Bosmina;* of the other chitinous skins the two furthest to the right are shell-parts of *Bosmina,* the central one of a bottom-*Daphnia* probably *Chydorus* or *Alona.* To the right of the plate 3 »stars«: *Pediastrum* most likely *P. boryanum;* in the middle a lump of excrements from *Chironomus* corroded in the edges, but typical in form. In the deeper part of the slide are numerous, very small remnants of bottom Diatoms and Chlorophycees chiefly *Pediastrum* and *Scenedesmus*, but as it was impossible to adjust the chitinous-skins in the same plane with the Diatomee-remnants, the latter have not come out in the photo.

The 15 of July plankton consisted of huge quantities of *Bosmina, Daphnia* and *Copepoda*; plankton Diatoms were completely wanting. Bagsværdsö not having been included in these plankton-explorations, we have no regular observations from this lake, but samples taken in April and January show, that Diatoms are almost wanting in the lake, and various samples taken during the summer that the Crustacea at this period have enormous maxima.)

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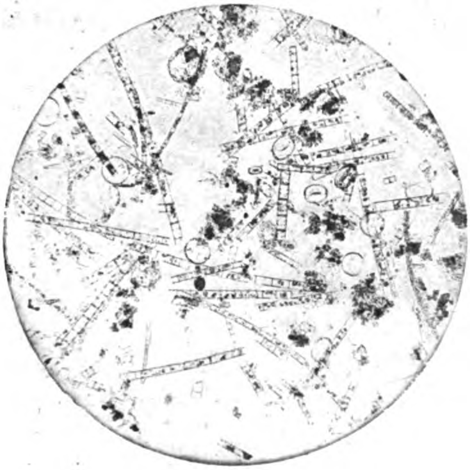

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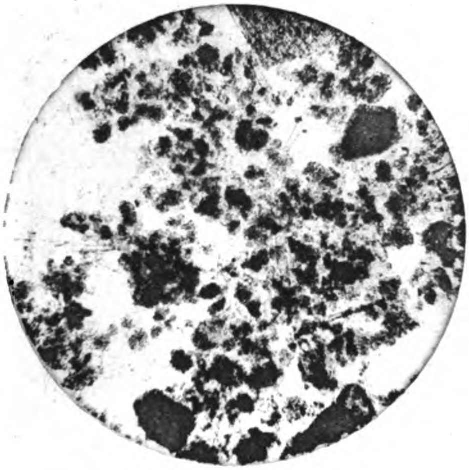

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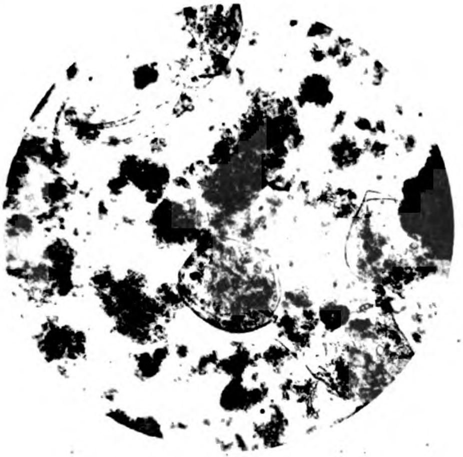

E. Aagaard hel. Max Kleinsorg impr.

Wesenberg-Lund
1900

Hrn. Dr. Kofoid
hochachtungsvoll
vom Verf.

Von dem Abhängigkeitsverhältnis zwischen dem Bau der Planktonorganismen und dem spezifischen Gewicht des Süsswassers.

(2)

Von

Dr. Wesenberg-Lund, Kopenhagen.

Sonderabdruck aus dem „Biologischen Centralblatt“.
Band XX. Nr. 18 u. 19, ausgegeben am 15. September u. 1. Oktober 1900.

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1909.

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Von dem Abhängigkeitsverhältnis zwischen dem Bau der Planktonorganismen und dem spezifischen Gewicht des Süßwassers.

Von Dr. **Wesenberg-Lund**, Kopenhagen.

Es ist eine bekannte Thatsache, dass, nachdem man darüber klar geworden, dass auch im Süßwasser sich eine pelagische Fauna befinde, und namentlich nachdem die Plantonuntersuchungen rücksichtlich der Tier- und Pflanzenfauna, welche das Plankton bilden, einen stärkeren Aufschwung genommen haben, eine sehr grosse Anzahl neuer Arten aufgestellt worden ist. Die Reaktion gegen diese recht unwissenschaftliche Artmacherei hat sich in den letzten Jahren eingefunden, und man hat begonnen, innerhalb verschiedener Gruppen eine sehr umfassende Reduktion vorzunehmen. So haben Stingelin [13], Stenroos [12], Richard [9], Burckhardt [2] u. a. die den Familien *Daphnide* und *Bosminide* angehörigen zahlreichen Arten zu einer weit geringeren Anzahl zusammenzuziehen gesucht und die ganze Hauptmenge als Varietäten oder Formen um einzelne, augenscheinlich höchst variable Arten zu gruppieren. Eine ähnliche Reduktion ist auch von Rousselet [10], Weber [15] u. a. rücksichtlich der Rotiferen angefangen; auch ich selbst habe in Untersuchungen, die jedoch nur zum geringen Teil publiziert sind, an diesem Stoffe gearbeitet und bin, die Anueräen anlangend, wesentlich zu demselben Resultat gekommen wie frühere Untersucher.

Es scheint, als ob die Arten einer Tiergruppe, die als Plankton-

1909.

organismen auftreten, einer weit größeren sowohl Lokal- als Tempor variation unterworfen sind als die der gleichen Tiergruppe angehörig Arten, die entweder Bodenformen sind oder der litoralen Region an hören. Es muss für den Augenblick dahingestellt bleiben, ob dieses I sultat als ein wirklich korrektes anzusehen ist oder nur als ein v läufiges, dadurch bewirkt, dass unsere Kenntnis von dem Variierun vermögen der Planktonorganismen im Augenblicke größer scheint von dem Variierungsvermögen der verwandten Bewohner der kleine Wassermassen oder der litoralen Region.

Ich werde hier nur einige Phänomene zusammenstellen, die inn halb weit verschiedener Tier- und Pflanzengruppen durch die Arbei vieler verschiedener Forscher gewonnen sind, und diese durch ein neue vermehren, die meine eigne Planktonuntersuchungen an den T gebracht haben. Ich glaube, dass dadurch ein besseres Verständ dieser Phänomene erreicht werden kann, dass man tiefer in die Ken nis der äusseren Faktoren dringe, welche die starke Variierung un den Planktonorganismen hervorrufen.

Es war erst G. O. **Sars** (1891), dann **Zacharias**, der 18 [17] und später 1894 [18] auf die Veränderungen aufmerksam mach welche die Kontur des Kopfes bei den zu dem, übrigens ganz unha baren Genus *Hyalodaphnia* gehörenden Arten im Laufe des Jahres leiden, und nachwies, dass der sogenannte Helm oder Crista beins gar nicht bei den Winterindividuen gefunden wird, sich in der Frühlin zeit in geringem Grade entwickelt, im August und September ein Ma mum erreicht und im Herbst wieder verschwindet.

Zu ähnlichen Resultaten kamen auch **Lundberg** [8] (1894), A stein [1] (1896), **Stenroos** (1898) und **Burckhardt** (1900). Wof die zwei Arten *H. cristata* G. O. Sars und *cucullata* G. O. Sa (*Jardinii* Richard) als besondere Arten auseinander gehalten wer sollen, scheint es, dass man für beide eine gleichartig verlaufe Temporalvariation annehmen muss.

Innerhalb des Geschlechtes *Daphnia* hat namentlich **Burckhar** was *D. hyalina* Leydig betrifft, durch seine regelmäßigen Untersuchung des Vierwaldstättersees konstatieren können, wie auch diese Fo im Winter mit einem niedrigen, flachen Kopfe auftrat, welcher spä im Jahre eine schwach entwickelte Crista erhielt, die zuletzt so sta hervortretend wurde, dass man im Juli-September die typische *D.* *leata* G. O. Sars vor sich hatte. Im Herbst verschwanden dann mälig die großbehelmten *D. galeata*-Formen, um den flachstirnig *D. hyalina var. brachycephala* Platz zu geben. Mit der stärkeren E wicklung des Helms folgt gewöhnlich auch eine Verlängerung Dornes, dergestalt, dass dieser meistens am längsten bei den hel tragenden Individuen ist und also stärker entwickelt bei den Somm als bei den Winterindividuen.

Bei meinen regelmäßig jeden vierzehnten Tag vorgenommenen Untersuchungen des Fursees und Frederiksborg-Schlosssees habe ich in den ersterwähnten Variationen der Helm- und Dornbildung bei *D. hyalina* gefunden, in dem letzteren bei *D. culcullata*, ganz denjenigen entsprechend, die andere Verfasser vor mir nachgewiesen haben.

Es ist kaum möglich, durch die Litteratur eine klare Vorstellung von der temporalen Variation bei den *Bosminen* zu bekommen. Hoffentlich werden Burckhardt's hierüber angekündete Untersuchungen etwas Licht in die Sache bringen. — Soweit meine eigenen Beobachtungen vorläufig gehen, bieten die Bosminen temporale Variationen wesentlich in drei Richtungen dar: in der Länge der Antennen, der Mucrones und in dem Kontur des Dorsalrandes des Körpers. Während in den dänischen Seen im Winter *B. longirostris* O. F. M. var. *cornuta* Yurine in ihrer typischen Form mit kurzen, in der Spitze stark gebogenen Antennen, kurzen Mucrones und schwach gewölbter Rückseite als gemeiner Planktonorganismus haust, wimmeln die Gewässer in der Frühlingszeit zugleich von Individuen mit langen Antennen und Mucrones und einem, namentlich vorne stark gewölbten Dorsalrand (*B. longirostris* O. F. M.) In vielen Gewässern ist in der wärmsten Sommerszeit die *B. longirostris* die allgemeine Form, in anderen *var. cornuta*, und in einzelnen treten sie durchgehend gleichzeitig mit einander auf; in allen aber wird gegen den Winter *var. cornuta* die am häufigsten auftretende.

Jeden Sommer werden jedenfalls eine große Anzahl unserer Seen von Bosminen bevölkert, die durch einen mehr oder weniger stark auswärts gebogene Dorsalkontur charakterisiert sind; dieses Verhältnis kann sich dermaßen entwickeln, dass das Tier in hohem Grade buckelig wird, und der Rücken sich demnach als eine sehr hervortretende, zapfenförmige Partie ausgedehnt hat. Je weiter man gegen den Sommer kommt, desto stärker entwickeln sich die Buckel und desto mehr buckelige Individuen trifft man. Gegen den Herbst verschwinden diese Formen und fehlen ganz in den Planktoneinsammlungen des Winters. Durch genaue, alle 14 Tage vorgenommene Untersuchungen des Fursees habe ich, was diesen See betrifft, konstatieren können, dass die schwach gebuckelten Formen *B. coregoni* Baird sich im April zeigen, im Juni wird die Buckelbildung stärker, und im August und Anfang September erscheinen die höchst barokken Formen, welche die Namen *gibbera* Schödler und *thersites* Poppe bekommen haben. Gleichzeitig mit der Vergrößerung des Buckels verlängern sich auch die Antennen, so dass diese im Herbst viel länger sind als im Frühling. Dass alle diese Formen zu derselben Art *B. coregoni* gehören, ist außer allen Zweifel; diese Reduktion ist schon von Stingelin angeregt worden; dass man es hier mit einer Temporalvariation zu thun hat, scheint dagegen nicht früher klar dargelegt worden zu sein. Wie diese Formreihe sich im Winter verhält, ist mir unbekannt. Nie habe

ich hier Dauereier gesehen, wiewohl diese mir von Untersuchung
über die Fauna Grönlands wohlbekannt sind. Ich bezweifle, da
irgendwelche Bosminenart des Fursees im Ruhestadium überwinte
in 6 Vertikalfängen von den Monaten November bis Februar fehlt
*B. coregoni*gruppe vollständig, wogegen *B. longirostris* namentlich
var. cornuta sehr zahlreich vorhanden ist; ich sehe es daher nicht
ganz ausgeschlossen an, dass die *B. coregoni*gruppe eine Sommerfo
der *B. longirostris*gruppe sei.

Bei den übrigen Planktoncladoceren hat man bis jetzt noch kei
Temporalvariation nachgewiesen. Recht charakteristisch verschwind
zufolge den Untersuchungen sämtlicher Beobachter eben alle di
Formen, nämlich die *Planktonsidien*, *Holopedium*, *Bythotrephes* u
Leptodora im Winter vollständig von der pelagischen Region; *Daphne*
brachyura ist diejenige von diesen Formen, die sich am längsten h
doch habe ich sie nie in den Monaten Januar-März gefunden;
scheint, als ob die starke, leicht nachzuweisende temporale Variati
innerhalb der Daphnien nur bei den Formen auftritt, welche sowo
im Sommer als im Winter Planktonorganismen sind.
Copepoden ist Temporalvariation nicht nachgewiesen.

Gehen wir nun von den Crustaceen zu den *Rotiferen* über,
finden wir bei diesen ganz ähnliche Verhältnisse.

Polyarthra platyptera findet sich das ganze Jahr hindurch
typischer Planktonorganismus in sozusagen allen größeren sowohl
kleineren Seen und Teichen. Die typische Form, die zu jeder Z
gefunden wird, hat die Form eines länglichen Prismas und trägt
schmale, längs des einen Randes sägeförmig ausgeschnittene Dorne
die Jungen sind zugespitzt kegelförmig, und die Hauptmasse d
Winter-*Polyarthra* besteht aus diesen jüngeren Individuen. Im M
zeigt sich die wohlbekannte Sommervarietät *euryptera* Wierzejski dur
bedeutende Größe, eine mehr quadratische Form und breite, längs d
beiden Seiten sägeförmig ausgeschnittene Blätterformen charakterisie
Im Anfang ist sie nur selten in dem Plankton, in der Sommerz
aber nimmt sie zu und verschwindet wieder im November. In gewiss
Seen ist sie im August-September alleinherrschend, in anderen zuglei
mit der typischen, und kann in einigen auch ganz fehlen. Die Variet
wird von Lauterborn [6] als Sommerform angegeben; Burckhard
der sich mit dieser Art beschäftigt hat, hat sich nur wenig mit d
Temporalvariation abgeben können, teilt aber andere sehr interessan
Wahrnehmungen mit.

Was die *Synchaeten* anlangt, so treten hier Verhältnisse auf, a
welche die Aufmerksamkeit bis jetzt noch nicht gelenkt worden i
und die mir nicht ganz klar sind. Ich anerkenne, was auch ande
wärts näher begründet werden soll, nur zwei im Süßwasser auftreten
Synchaetaarten', nämlich: *S. pectinata* Ehr. und *S. tremula* Goss

nur die erste scheint einer Temporalvariation unterworfen zu sein. Man trifft den ganzen Winter hindurch in zahlreichen Seen und Teichen eine kleine Form von *S. pectinata*, durch die gewöhnlichen Hauptkennzeichen: die gewölbte Radscheibe, die beilförmigen Antennen und kurze Exkretionskanäle charakterisiert, aber abweichend darin, dass sie nur 0,18 bis 0,2 Millimeter lang, gelblich und wenig hyalin ist, und ihre Eier trägt; außerdem endet der Körper hinten in einem kleinen, mehr oder weniger deutlich in der Spitze gespaltenen Zapfen. Diese Form wird in dem Folgenden als *minor* bezeichnet. Gleichzeitig trifft man, aber in weit geringerer Anzahl, die typische 0,4 Millimeter große, stark gewölbte Hauptform, deren Hinterteil den oben erwähnten Zapfen nicht aufweist. Diese Form nimmt im April-Mai stark zu, gleichzeitig wimmelt das Wasser von jungen, langgestreckten 0,2 bis 0,3 Millim. langen, äußerst hyalinen Tieren, die Jungen der Hauptform, von Gosse als *S. longipes* beschrieben. Den ganzen Sommer hindurch war dann an den meisten Lokalitäten *S. pectinata* Hauptform, nahm aber gegen den Herbst an Anzahl ab. In den pelagischen Partien der grossen Seen trat im Juli-August die von Zacharias als *S. grandis* (Forschungsber. T. 1. 1893) beschriebene sehr langgestreckte Form auf, welche im September wieder vollständig verschwindet. Die Verhältnisse komplizieren sich indessen noch dadurch, dass die Winterform *minor* keineswegs immer mit dem Sommer verschwindet, sondern sich an einigen Orten, besonders in grösseren Seen, das ganze Jahr hindurch hält. Diese Sommerindividuen von der Form *minor* zeichnen sich dadurch aus, dass der Zapfen des Hinterteils sich hier in eine längere oder kürzere stabförmige Partie ausdehnt (*S. stylata* Wierzejski?), die mitunter die halbe Länge des Körpers erreichen kann. In den von mir untersuchten Seen habe ich nie ein Sommerindividuum die Eier tragen sehen. In dem Fursee und 11 kleineren Seen und Teichen, wo ich alle 14 Tage die Verhältnisse untersucht habe, ist *minor* immer die Hauptform des Winters und *S. pectinata* Ehr. im Frühling im Zunehmen gewesen. Diese haben sich in den kleineren Seen den ganzen Sommer unverändert gehalten. In dem Fursee war in der wärmsten Sommerzeit auch *var. grandis* vorhanden; in demselben See, aber auch in einzelnen kleineren, fand sich in der Sommerzeit *minor*, aber mit stabförmigen Hinterteilsanhang; gegen Winter verschwanden diese Formen, *minor* ausgenommen.

Meine Auffassung ist also folgende: Von *S. pectinata form. minor* entwickeln sich im Frühling und im Laufe des Sommers teils Individuen, welche den Winterformen gleichen, aber einen stabförmigen Anhang tragen (*S. stylata* Wierz), teils die große, hyaline beinahe fußlose typische *S. pectinata*, welche unter besonderen Verhältnissen als *S. grandis* (Zacharias) endet.

Die Untersuchungen über die Biologie und Morphologie der *As-*

planchnen haben mich dahingeleitet, nur vier Arten anzuerken *A. priodonta* (Gosse), *Brightwelli* (Gosse), *Herrichi* (de Guerne) *Sieboldii* (Leydig). Temporalvariation ist bis jetzt nur bei *A. priod* nachgewiesen. Die Art wird den ganzen Winter hindurch regelm in Seen und Teichen gefunden, aber zu dieser Jahreszeit nur in ringer Anzahl, und die parthenogenetische Fortpflanzung ist sehr s herabgesetzt oder fällt beinahe ganz weg. Einige Zeit nach dem treten der ersten Sexualperiode (Mai) kann man konstatieren, die Individuen nun bedeutend länger sind als im Winter; unter di Form ist die Art, besonders in den großen Seen, als *A. helve* (Imhof) bezeichnet worden. Die Individuen vergrößern sich bestän je weiter man in den Sommer hineinkommt. Die Maximallänge im August-September erreicht; nach der zweiten Sexualperiode (S Oktober) finden sich wieder nur die kurzen, plumpen Formen. Wäh das Verhältnis zwischen Länge und Breite bei den Winterformen 1 : 1¹/₂ war, war dasselbe Verhältnis bei den Sommerformen gew lich wie 1 : 2 bis 2¹/₂. Ausnahmsweise habe ich in den größe dänischen Seen das Verhältnis 1 : 5 gefunden und in diesen Fä sehr langgestreckte, wurstförmige Asplanchnen vor mir gehabt, vielle die grössten aller Rotiferen, 3¹/₂ mm. Ganz wie bei *Polyarthra* und *S chaeta* findet man auch im Sommer die kürzere und plumpere Win form wieder, in einigen Seen in großer Anzahl, in anderen bein von der Form *helvetica* verdrängt.

Auch bei *Triarthra longiseta* Ehr. tritt eine obwohl geri Temporalvariation auf; die Art ist allgemein den ganzen Winter; während die Dornen der Winterformen selten mehr als 0,2 bis sind, sind sie bei den Sommerformen, namentlich in den großen S 0,6 bis 0,8 mm. Es ist zum Teil dieses Verhältnis, was Zachar veranlasst hat, var. *limnetica* (Forschungsber. Thl. 1893) aufzustel Was die *Anuraeen* betrifft, so kann ich mich in allem Wesentlichen von Weber gegebenen Begrenzung der Arten anschließen; von von Weber angenommenen 4 Typen sind die zwei Arten *A. cochle* (Gosse) und *A. aculeata* (Ehr.) einer bedeutenden Variation un worfen. Bei regelmäßig alle 14 Tage betriebenen Untersuchungen Planktons in 12 Seen und Teichen habe ich das ganze Jahr hindu konstatieren können, dass diese zwei Arten einer weit stärkeren Lo als Temporalvariation unterworfen sind, und dass die Individuen pelagischen Region der großen Seen mit einem eigenartigen, bein überall gleichen unterscheidenden Charakter den äußerst verschieden zahlreichen, besonders in der Sommerzeit auftretenden Varietäten niedrigeren Teiche gegenüberstehen. Doch haben die Untersuchung des Planktons des Fursees gezeigt, dass man auch bei den Anurae arten in den größeren Seen eine, was die Länge der Dornen betr allerdings nur geringe Temporalvariation nachweisen kann.

Imhof's *A. longispina* = *A. cochlearis* mit ungemein langem Hinterdorn und *A. aucleata* var. *regalis* desselben Verfassers mit zwei überaus langen Hinterdornen sind Sommerformen, die im Juli-August regelmäßig in dem Fursee auftreten und wieder verschwinden. Genaue, regelmäßige Beobachtungen der Anuraen in diesem See haben erwiesen, dass die Dornen unbedingt länger sind bei den Sommer- als bei den Winterindividuen. Die in dem Plankton der großen Seen von allen in niedrigeren Teichen auftretenden Anuraea-Varietäten gewöhnlichste ist meinen Beobachtungen zufolge *A. cochlearis* var. *tecta* (Gosse), charakterisiert durch das Fehlen des Hinterdornes. Diese Form wird von Apstein und Lauterborn (6 u. 7) als Sommervarietät angegeben; in zwei der von mir untersuchten kleineren Seen ist *A. tecta* zwei Jahre nach der Reihe die Hauptform des Winters gewesen, wie ich sie auch in den Planktoneinsammlungen des Winters von vielen anderen Seen gefunden habe. Sie findet sich das ganze Jahr hindurch, ist aber in den beiden erwähnten Seen im Winterhalbjahr durchaus am zahlreichsten gewesen; sie kann mehrere Monate des Sommerhalbjahres vollständig fehlen. Nähere wahrscheinlich sehr eingehende Untersuchungen über die Variation der Anuraen sind übrigens von Lauterborn angekündigt.

Bei den übrigen Planktonrotiferen hat man bisher keine Temporalvariation nachweisen können. Alle diese, namentlich *Hudsonella*, *Gastroschza*, *Mastigocerca*, *Pompholyx*, *Chromogaster*, *Pedalion*, *Schizocerca* und *Notholca longispina* (Kellicott) sind ohne Ausnahme Sommerformen. Auch innerhalb der Rotiferen trifft man das Phänomen, dass die temporale Variation nur bei den Formen, die sich das ganze Jahr finden, stark hervortretend ist, aber bei den Formen, die nur im Sommerhalbjahre vorhanden, bisher nicht erweislich ist.

Bei den Planktonrhizopoden, die alle in kurzen scharf begrenzten Perioden in dem Plankton erscheinen, hat man noch keine Temporalvariation nachgewiesen.

Dasselbe gilt auch von den Planktoninfusorien. Indem wir hier von einigen seltenen Formen, wie *Staurophrya elegans* Zacharias u. a. absehen, treten hier im Lande *Codonella lacustris* Entz, *Tintinidium fluviatile* Stein und *Dileptus trachelioides* Zacharias als allgemeine Planktoninfusorien auf. Bei den zwei ersteren habe ich auch keine Temporalvariation nachweisen können. *Codonella lacustris* findet sich zwar das ganze Jahr hindurch, ist aber in der Sommerzeit sehr selten, häufiger im Herbst und im Winter und hat in verschiedenen von unseren Seen 1897 im April ein enormes Maximum gehabt, worauf sie von Mai selten wurde. *Tintinidium fluviatile* habe ich im Dezember erst einzeln nachweisen können; die Anzahl stieg im April-Mai, worauf die Art vollständig verschwand; ganz derselbe Entwicklungsgang ist von Apstein und Zacharias angegeben worden. Einen Unterschied zwischen den Sommer- und Winterindividuen habe ich nicht na weisen können; die nicht geringe Anzahl von gewiss recht zwe haften Arten, die innerhalb der Tintinidien von v. Daday [3] aufges sind, lassen eine ziemlich starke Lokalvariation vermuten.

Ganz andere und weit eigentümlichere Verhältnisse habe ich *Dileptus trachelioides* gefunden. In mehreren dänischen Seen habe des Winters ein beinahe kugelrundes $^{1}/_{2}$ Millimeter langes Infuso gefunden, dass ich ohne Bedenken zu *Trachelius ovum* Ehr. ste es war mit einem ziemlich kurzen, aber äußerst formwechseln Rüssel versehen, an dessen Grund der Mund sich fand. Im April- fand ich in denselben Gewässern ein viel größeres, beinahe 1 Mil langes Infusorium, länglich wurstförmig, bald mit einem sehr lan bald mit einem sehr kurzen Rüssel ausgestattet. Der ganze Kö des Tieres, aber ganz besonders die hintere Hälfte enthielt zahlre einzellige Algen, die das Tier grün färbten. Dass ich in diesem F *Dileptus trachelioides* vor mir hatte, war sicher genug. Im Juni merkte ich, dass in den erwähnten Seen das Vorderende aller Ex plare in 2—3 lange, dünne Zipfel ausgezogen worden waren, de Länge der des Körpers entsprach, und in ganz niedrigen war Seen (die Dünenseen bei Raabjerg (Skagen) war zu Ende Mai Vorderende des Tieres in 4—5 äußerst dünne Zipfel ausgezogen, de Länge selbst die des Körpers übertraf. Ich bin geneigt, in *Am leptus flagellatus* Rousselet, *Trachelius ovum* Ehr, *Dileptus trachelio* Zacharias eine und dieselbe Art zu sehen, die einer großen Tempo und wahrscheinlich auch Lokalvariation unterworfen ist. Hier das Gewicht auf die Thatsache gelegt werden, dass die Form Winter eine kurze, beinahe kugelrunde ist, dass sie in denselben wässern gegen Frühling länglich wird und dass zuletzt in den Mona Mai-Juni das Vorderende zahlreiche Zipfelbildungen aussendet. muss noch hinzufügen, dass *Trachelius ovum* sich im Sommer den kleinen Seen hält und in den großen verschwindet. Es soll bemerkt werden, dass die Tiere in der Konservierungsflüssigkeit Zipfel einzogen und sich kugelförmig abrundeten. Ich vermute, d es diese Zipfelbildungen sind, die Zacharias erwähnt, wenn (Forschungsber. T. II, pag. 81) die zahlreichen monströsen Individ hervorhebt.

Innerhalb der Peridineen ist Temporalvariation bis jetzt nur *Ceratium hirundinella* O. F. M. nachgewiesen, und auch ich habe nur bei dieser einen Art konstatieren können. Lauterborn, Apst und Zacharias haben alle die Temporalvariation nachgewiesen, a während Lauterborn beobachtet haben will, dass die Art im Frühl in ihrer breiten Form mit 4 Hörnern auftritt und im Herbst schl und zuletzt schmal mit nur drei Hörnern endet, behaupten Apstein Zacharias im Gegenteil, dass man im Frühling die schlanke, dreihörn

Form trifft und im Herbste die breite vierhörnige. Später (Forschungsber. T. 6, pag. 106) macht Zacharias auf die Lokalvariation aufmerksam. Wie frühere Untersucher, habe ich im März-April einzelne Exemplare gefunden, im Juli-August ein Maximum beobachtet — in einigen kleineren Seen und Teichen erst im September —, habe die Art im November verschwinden sehen und einzelne Exemplare im Dezember nachweisen können.

Das wesentlichste Resultat der Untersuchungen ist dieses gewesen, dass *Ceratium hirundinella* einer außerordentlich starken Lokal- und Temporalvariation unterworfen ist. Die Ceratien der pelagischen Region der großen Seen stehen mit einem eigenartigen schlanken Gepräge denen gegenüber, die den niedrigeren Teichen gehören. Im Fursee ist die Entwicklung in der von Apstein und Zacharias angegebenen Richtung gegangen: von schlanken dreihörnigen Formen zu breiten vierhörnigen. Eine Massenuntersuchung der Ceratien von größeren Seen im Mai gab überwiegend dreihörnige Formen, eine ähnliche in August von denselben Seen überwiegend vierhörnige. Alle 14 Tage vorgenommene Untersuchungen der kleineren Seen und Teiche konstatierten gleichzeitig, dass die Ceratien entweder keiner Temporalvariation unterworfen waren, indem sie das ganze Jahr hindurch vierhörnig waren, oder sich verhielten, wie Lauterborn es angibt (vierhörnig im Frühling und dreihörnig später im Jahre).

Innerhalb der Chrysomonadinen hat man bisher keine Temporalvariation nachgewiesen. Wie bekannt, variieren die Dinobryonen außerordentlich stark, was Veranlassung dazu gegeben hat, dass eine große Anzahl (ca. 15) durchgehends wenig haltbarer Arten beschrieben worden ist. Alle in Kolonien lebenden Arten lassen sich, wie auch Zacharias (Forschungsber. T. I. 1893) früher gethan, auf zwei Haupttypen zurückführen: *D. sertularia* Ehr. und *D. stipitatum* Stein. Wie Zacharias sehe ich *D. elongatum* Imh. und *bavarium* Imh. als Planktonformen von *stipitatum* an, und *D. divergens* Jmh. als Planktonform von *D. sertularia*; die übrigen Imhof'schen Arten werden wohl nur eine Lokalform der *D. sertularia* sein. Uebrigens finden sich alle möglichen Uebergänge zwischen *D. sertularia* und *stipitatum*.

Ganz wie Apstein und Zacharias habe auch ich, was die großen Seen anbetrifft, im März und April *D. stipitatum* und *sertularia* var. *divergens* ganz gleichzeitig angetroffen, sie beide den ganzen Sommer beobachtet und sie im November verschwinden sehen; doch habe ich in zwei nach einander folgenden Jahren bemerkt, dass *D. stipitatum* var. *divergens* im Frühling und Herbst häufig waren und dass die wenigen Winterexemplare, die ich in dem Plankton der größeren Seen nachweisen konnte, immer zu dieser Form gehörten, während *D. stipitatum* immer häufiger im Sommer und Spätsommer war; ganz dasselbe geht auch, was die Ploenerseen betrifft, aus Za-

D

charias Planktontabellen hervor. Gleichzeitige vierzehntägige Un
suchungen der kleinen Seen bewiesen auch, was schon Zacharias
erwähnt hat, dass *D. sertularia* weit häufiger in den kleinen S
und Teichen ist als *D. stipitatum*, und dass *D. sertularia* den gan
Winter hindurch in nicht geringer Anzahl in kleinen Gewässern
funden werden kann.

Da nun alle mögliche Uebergänge zwischen *D. sertularia* u
D. stipitatum sich finden, meine ich, dass *D. stipitatum* in den gro
Seen wesentlich als Sommerform für *D. sertularia* betrachtet wer
kann. Am richtigsten sagt man wohl: dass die Dinobriumkolon
der großen Seen in der Sommerzeit eine Tendenz zur Verlängeru
des Stiels der Gehäuse und zu spitzeren Winkeln zwischen den e
zelnen Zweigen der Gehäuse zeigen; gegen Herbst werden die St
wieder kürzer, die Winkel breiter; wir haben wieder *D. sertula*
vor uns.

Bei den Mallomonaden habe ich keine Temporalvariation na
weisen können.

Dieses ist auch mit den Chlorophyceen der Fall. Verschied
Beobachtungen über die zu der pelagischen Region der großen S
gehörigen *Pediastrum*-Arten haben mich vermuten lassen, dass m
hier nicht vergebens eine Temporalvariation suchen würde. Da ich
indessen mit meinen wenigen Beobachtungen ganz allein stehe,
ich nur als eine Vermutung andeuten, dass genauere Untersuchung
vielleicht nachweisen werden, das *P. pertusum* Ktzg, hauptsächl
eine Sommerform des das ganze Jahr gegenwärtigen *P. boryanum* Men
sei; ich werde jedoch in dem folgenden diese Formen nicht berü
sichtigen.

Temporalvariation ist auch nicht bei Cyanophyceen nachgewies
und als ausgeprägte Sommerformen, die sich erst im April zei
und gewöhnlich im Oktober-November verschwunden sind, muss m
im Voraus vermuten, dass eine solche kaum stark hervortretend s
würde.

Anders verhält es sich wahrscheinlich mit den Diatomeen.
ist mir bei diesen Formen, namentlich bei den vierzehntägigen Un
suchungen in dem Plankton des Fursees auffallend gewesen, wie v
schiedenartig die Anzahl der Einzelindividuen in den Kolonien zu
verschiedenen Jahreszeiten ist. Während die Asterionellen gewöhnl
einen Stern aus 12—14 Individuen gebildet haben, fand ich im Win
oft über 20; im Mai war die Hauptmasse der Sterne aus 7—8 In
viduen zusammengesetzt. Gleichzeitig fanden sich die Asterionel
der kleineren Seen nur als vierstrahlige Kolonien. Aehnliche
obachtungen können bei den Fragilarien angestellt werden; a
genauere Untersuchungen müssen die Ursachen und die Bedeutu
dieser noch wenig aufgeklärten Verhältnisse entscheiden.

Stellen wir nun in Kürze die hier erwähnten Beobachtungen zusammen. Wir fanden, dass bei den *Hyalodaphnien* und *Daphnien* die Länge der Helme und der Hinterdorne zunahm, je weiter man in den Sommer hineinkam, dass diese gegen den Herbst kürzer wurden und dass die Individuen im Winter keine oder sehr kurze Helme und kürzere Hinterdornen hatten.

Bei den *Bosminen* verlängern sich im Frühling die Antennen und Mucrones, oder der Dorsalrand des Schildes zieht sich buckelförmig aus, wobei eine Art Helmbildung auf dem Rücken des Tieres entsteht, während auch bei diesen Formen die Antennen sich verlängern. Im Winter sieht man nie Individuen mit Buckelbildung, die Hauptmasse der Winterbosminen hat kurze Antennen und kurze Mucrones. Innerhalb der Rotiferen wird die Temporalvariation bei *Polyarthra* im Sommer durch eine starke Entwicklung der Dornen — von dünnen Nadeln zu breiten, flachen Rudern — charakterisiert. *Synchata pectinata* tritt im Winter hauptsächlich als die oben erwähnte forma *minor* auf, in der Frühlings- und Sommerzeit entwickeln sich teils Formen, die den Winterindividuen gleichen, teils vermehrt sich die typische große *S. pectinata* stark in Anzahl, und in der pelagischen Region der großen Seen zeigen sich im Juli-August die großen langgestrekten Individuen, die als *S. grandis* bezeichnet worden sind. Bei *Asplanchna priodonta* kann man, wenn man die Sommer- und Winterexemplare vergleicht, einen bedeutenden Unterschied zwischen der Breite und Länge der Tiere konstatieren, indem die Sommerindividuen durchgehends länger sind, als die des Winters. Endlich sind bei *Triarthra* und *Anuraea* die Dornen länger im Sommer als im Winter.

Den Daphnien und Rotiferen betreffend bemerken wir ferner, dass die temporale Variation immer bei den Formen am stärksten scheint, die das ganze Jahr hindurch als freibewegliche Planktonorganismen leben, wogegen sie, wenigstens bis jetzt nicht bei den Formen nachweislich gewesen ist, die ausschließlich Sommerformen sind und in Ruhestadien überwintern.

Innerhalb der Infusorien kann man *Dileptus trachelioides* betreffend nachweisen, dass in denselben Gewässern der typische *Trachelius ovum* im Winter allgemein ist, im Frühling mehr langgestreckte Formen auftreten und dass diese Formen, die wahrscheinlich der typische *D. trachelioides* ist, Mai-Juni das Vorderende in drei bis fünf dünne Zipfel ausgezogen bekommen, wonach das Tier aus dem Plankton verschwindet.

Eigene Untersuchungen über *Ceratium hirundinella* geben für die größern Seen dasselbe Resultat als Apstein's und Zacharias Untersuchungen, nämlich, dass im Herbst eine größere Dornbildung stattfindet. Bei den *Dinobryen*kolonien besteht eine Neigung zur Verlängerung der Stiele der Gehäuse, während gleichzeitig die Winkel zwischen den

1909.

D

Zweigen spitzer werden; die Winterexemplare zeichnen sich breitere Winkel und stiellose Gehäuse aus.

Indem wir nun dazu übergehen die Lehren zu ziehen, di Thatsachen enthalten, würde es vielleicht natürlich sein hervorz dass sie keineswegs von dem einzelnen Untersucher herrühren, dass die, welche die *Hyalodaphnien*, *D. galeata*, *Polyarthra* un *tium hirundinella* betreffen, zu verschiedenen Zeiten, von m Forschern, an ganz verschiedenen Orten bestätigt worden si dass andere *(Dileptus, Dinobryum)* teilweis gesehen worden (Zach wenn auch gewiss nicht als Temporalvariationen verstanden u gefasst. Man operiert also nicht mit zweifelhaften, ungenüg gründeten Resultaten, sondern zum Teil mit gut geprüften schaftlichen Thatsachen.

Es geht, wie es mir scheint, ganz deutlich aus den ange Mitteilungen hervor, dass die Umbildungen, welche alle die c wähnten Planktonorganismen, welcher systematischen Gruppe s angehören, im Laufe des Jahres erleiden, bei allen glei in derselben Richtung gehen, immer dasselbe große, gemeinsch Ziel anstreben. Denn die Verlängerung des Helms und der dornen bei den Daphnien und Hyalodaphnien, die Ausbild Buckels bei den Bosminen, das Verflachen der Dornen bei *Pol* die Verlängerung des Hinterteilspitzes der Synchaeten, der der *Triarthra* und *Anuraea*, das Ausschießen der Zipfel bei *D* die vermehrte Dornbildung bei *Ceratium* und die Verlängeru Kelchstieles bei *Dinobryum* — Umbildungen die alle von April bis an Stärke zunehmen und wieder von September-Januar abnehmen sind sie anders als eine unverkennbare Tendenz zu ein stimmten Zeit des Jahres den Umfang der Organe z größern, die aller Wahrscheinlichkeit nach doch gendwelche Weise auf die Schwebefähigkeit des Einfluss üben, und den Umfang dieser Organe zu anderen Zeit wieder zu verringern?

Es liegt also nahe anzunehmen, dass sich ein gemeinscha äußerer Faktor findet, der jedenfalls alle die Planktonorga die das ganze Jahr auftreten, dazu zwingt, im Sommer ihre organe zu vermehren und im Winter wieder zu verkleinern.

Und dieser äußere Faktor ist, wie ich vermeine, die jähr und regelmäßigen Veränderungen in dem spezifisch wicht des Süßwassers, die zum wesentlichen Teil die Entwickelung der Schwebeapparate im Sommerhalbjahr veru Indem übrigens sowohl die Temperatur wie die Menge der auf Stoffe auf das spezifische Gewicht Einfluss haben, üben selbstv lich auch alle übrigen physikalischen Verhältnisse des Süßwasse Einfluss auf die Entwicklung dieser Schwebapparate aus.

Soweit mir bekannt, hat man merkwürdigerweise nie die Aufmerksamkeit auf den Einfluss gerichtet, den die Erwärmung der Seen im Frühling und die gleichzeitige Veränderung in dem spezifischen Gewicht des Wassers notwendigerweise auf das Leben der Planktonorganismen üben müssen. Es scheint, als ob die Untersucher des Süßwasserplanktons von der Voraussetzung ausgegangen sind, dass die Tragkraft des Wassers den Planktonorganismen gegenüber in einem gegebenen See das ganze Jahr hindurch vollständig dieselbe sein müsse. Nun verhält es sich aber so, dass das Wasser, wenn es im Frühling erwärmt wird, mit einer anderen und, wie wir aus dem Folgenden ersehen werden, wahrscheinlich weit geringeren Tragkraft den Planktonorganismen gegenüber stehen wird als im Winter bei niedriger Temperatur.

Die Frage ist also die, welche Mittel dem Individuum zur Verfügung stehen, wenn es sein spezifisches Gewicht den verschiedenen spezifischen Gewichten des Süßwassers accommodieren soll.

Zuerst vermeine ich, haben die Planktonorganismen in ihrem Stoffwechsel, besonders durch Ausscheiden und Aufnahme des Wassers einen innerhalb sehr enger Grenzen fungierenden hydrostatischen Apparat. Da die Planktonorganismen von einem obwohl dünnen, so doch festen aus Kiesel oder Chitin gebildeten Hautskelet umgeben sind, und da Hohlräume mit variablen Luftmengen nur selten vorkommen, glaube ich, dass die Grenzen für die Akkommodation, die einzig aus den Stoffwechselprozessen hervorgeht, sehr eng sind; bei dem Stoffwechsel können die Organismen sich möglicherweise den täglichen Oscillationen in der Tragkraft des Wassers anbequemen, aber werden auf diesemWege schwerlich im stande sein, ihr spezifisches Gewicht in Uebereinstimmung mit den weit stärkeren und regelmäßig jährlich wiederkehrenden Aenderungen im spezifischen Gewicht des Süßwassers zu bringen, wenn dieses in der Zeit Februar-August von 0 bis zu 24° C. erwärmt wird. Ich vermute also, dass während der Erwärmung der Seen in der Frühlingszeit, und zwar bei einer verschiedenen Temperatur bei den verschiedenen Planktonorganismen, der Zeitpunkt eintreten wird, wo die Organismen nicht länger imstande sind, sich in Uebereinstimmung mit der steigenden Temperatur zu erweitern und wo sie sich wahrscheinlich durch Wasserausscheidung von der Grenze ihrer Ausdehnung wegregulieren müssen, um nicht gesprengt zu werden. Wenn dieser Zeitpunkt kommt, wo also die Organismen mittelst der Wegregulierung von den Elastizitätsgrenzen sich nicht nach der mit der Erwärmung der Seen folgenden veränderten Tragkraft akkommodieren können, dann greifen sie zu andern Mitteln, dann fängt die Entwickelung aller der Schwebeorgane an. Ich erkläre diese also als einen Ausdruck für die Bestrebungen, die von Seiten der Organismen gemacht werden — wenn ihre

Stoffwechselprozesse nicht länger hinreichend sind —, um ihr eigen
spezifisches Gewicht in Uebereinstimmung mit der v
änderten Tragkraft des Wasser im Frühling zu bring
Veränderungen, die als ein äußeres Irritament auf
Organismen wirken.

In: Nr. 19.

Das Plankton ist indessen aus sehr verschiedenartigen Organism
zusammengesetzt und die Wege, die sie einschlagen, um sich den neu

S.

Verhältnissen anzupassen, sind auch sehr verschieden. Wir werden nun diese verschiedenen Wege kürzlich untersuchen und daraus erkennen, dass die obenerwähnten Temporalvariationen der äußeren Form nicht ein für die betreffenden Planktonorganismen alleinstehendes Phänomen ist, sondern das ganz entsprechende, demselben Zwecke dienende — die Schwebfähigkeit zu vergrößern — sich im Sommer wahrscheinlich bei allen Planktonorganismen finden werden.

Erstens können die Planktonorganismen ohne ihren Rauminhalt zu verändern ihr spezifisches Gewicht durch eine reichlichere Entwicklung von Stoffen (Fett, Oeltropfen), deren spezifisches Gewicht geringer ist als das des Wassers, vermindern und gleichzeitig Stoffe von höherem spezifischem Gewicht abgeben. Da der Oelreichtum, der zahlreichen Planktonorganismen eigen ist, z. B. Diatomeen, Copepoden, Daphnien zweifellos in Folge der Assimilation und Ernährung hervorgegangen ist, muss man vermuten, dass der Vorrat dieser Stoffe sich im Frühling wegen der höheren Temperatur, der stärkeren Lichtverhältnisse und des Bedürfnisses reichlicherer Nahrung bei den Organismen vermehren wird; hieraus folgt denn, daß die Organismen, sowie die Temperatur steigt, auf diesem Wege imstande sind, ihr spezifisches Gewicht zu vermindern. Da wir innerhalb des Planktons einige größere Gruppen antreffen, besonders die Copepoden, bei welchen wahrscheinlich keine Temporalvariation stattfindet, ist die Möglichkeit nicht ausgeschlossen, dass das wichtigste Accomodationsmittel dieser Tiere eben in der mit der Temperatur und Ernährung steigenden Oelproduktion zu suchen ist.

Wie bekannt giebt es einen großen Teil von Planktonorganismen, deren Schwebfähigkeit von der Ausbildung großer, in ihrem Inneren gelegenen luftgefüllter Hohlräume abhängig ist. Von dem Süßwasser kennen wir z. B. einzelne Infusorien (*Arcella*) zahlreiche Cyanophyceen, auch einzelne Oscillarien. Von diesen muss es bezweifelt werden, ob die Arcellen wirklich zu den Planktonorganismen gerechnet werden können; die Cyanophyceen sind hauptsächlich ausgeprägte Sommerformen, die im Winter beinahe vollständig aus dem Wasser verschwinden, und nur die Oscillarien scheinen das ganze Jahr hindurch vorhanden zu sein. Wir wissen vorläufig sehr wenig von dem Auftreten der letztgenannten Formen als Planktonorganismen; hierzulande fehlen sie kaum in irgend welchem unserer größeren Seen; hauptsächlich erscheinen sie als Frühlingsformen. In Analogie mit der Schwimmblase der Fische und von den vorzüglichen Untersuchungen Klebahns[5]) und Strodtmanns[14]) ausgehend, ist es im höchsten Grade wahrscheinlich, dass alle die obenerwähnten Organismen in diesen Luftvacuolen einen sehr empfindlichen Apparat besitzen, welcher an und für sich hinreichend ist, das spezifische Gewicht der Algen,

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sowohl was die täglichen als auch die jährlichen Variationen in spez. Gewicht des Süßwassers betrifft, zu regulieren.

Ferner können die Organismen das spezifische Gewicht Formveränderungen accomodieren.

Zwei Körper, deren Gewicht und spezifisches Gewicht das deren Form aber verschieden ist, sinken nicht gleich schnell; übrigens ganz gleichen Verhältnissen wird der Körper um so langs sinken, je länger im Verhältnis zu der Breitenachse die Längen ist, natürlicherweise vorausgesetzt, dass die Längenachse horizontal von allen Körperformen wird die Kugel am schnellsten sinken.

Denkt man sich nun zwei gleichgewichtige Planktonorganis die eine kugelrund, die andere torpedoförmig, in einer Flüssi deren spezifisches Gewicht um ein Minimum geringer ist als das Organismen, so kann die Muskelenergie, die erforderlich ist, un beiden Organismen in derselben Höhe zu halten, nicht bei beiden selbe, sondern muss bei der kugelrunden am größten sein. Betra wir nun, mit diesem Verhältnis vor Augen, die Temporalvariat bei Hyalodaphnien, Bosminen, Synchäten, Asplanch und Dinobryen, so werden wir gleich sehen, dass die Frühling änderungen bei allen diesen Formen in der Richtung gehen, die Län achsen (Horizontalachse der allgemeinen Stellung des Tieres vergrößern, wogegen sie im Herbste in der entgege setzten Richtung gehen; am besten lässt dieses sich bei den planchnen nachweisen, wo das Verhältnis zwischen Längen- Querachse im Winter wie $^3/_4$:1, im August wie 1:5 ist. Betra man eine *Bosmina* in der Stellung, in welcher sie gewöhnlich bildet wird, so scheint es freilich, als ob diese durch die Bu bildung nach der Querachse gestreckt ist. Die Stellung, in we die Bosminen gewöhnlich abgebildet werden, ist indessen nicht jenige, die sie im Wasser einnehmen; hier sieht man sie am häufi in einer schrägen Stellung mit der Rückseite abwärts schweben. ist daher ganz in Uebereinstimmung mit der Theorie, dass bei Bosminen die Querachse (unter die gewöhnliche Stellung der Tier Wasser die Horizontalachse) jene Achse wird, nach welcher die längerung stattfindet. Das Ziel, das bei dieser auf den ersten so äußerst frappierenden, gleichmäßig verlaufenden Temporalvari bei so vielen verschiedenartigen Planktonorganismen erstrebt wir also dieses, den Organismen, je nachdem die Tragkraft des Wa sich in der Frühlingszeit verändert, eine Form zu geben, die bei selben Muskelenergie schwebend gehalten werden kann als die Mu energie, die im Winter hinreichend war; in diesem Verhältnis muss die Erklärung der im Sommerhalbjahre stattfindenden Ver rungen bei Daphnien, Synchäten, Asplanchnen u. a. ge werden.

Endlich können die Organismen vielleicht ihre Schwebfähigkeit steigern indem sie ihre immer als Balanceapparate aufgefassten Dornenbildungen verlängern; diese Form der Temporalvariation findet man bei vielen Rädertieren, deren Dornen, wie schon erwähnt, im Sommer länger sind als im Winter (*Anuraea*, Brachionen, *Triarthra*, *Ceratium* u. a.) Der Vollständigkeit willen muss hienzugefügt werden, dass derselbe Organismus oft gleichzeitig mehrere dieser Wege einschlägt; so treffen wir bei den Daphnien Formveränderungen, Oelproduktion und Verlängerung der Hinterdornen.

Dass mit der Erwärmung der Seen in der Frühlingszeit eine Veränderung mit der Tragkraft der Wassermassen stattfindet und dass die Tragkraft in der warmen Sommerzeit eine andere sein muss als im Winter, ist einleuchtend. Bei derjenigen Kenntnis, die wir augenblicklich über die regelmäßigen, jährlichen Veränderungen in dem spezifischen Gewicht der Seen und über die Weise, worauf sich die Organismen nach diesen Veränderungen accomodieren, ist man indessen nicht imstande, sich eine völlig wissenschaftlich begründete Auffassung über die Richtung zu bilden, in welcher die Modifikationen in der Tragkraft des Wassers vor sich gehen.

Wenn man sich indessen aus den vorhergehenden Mitteilungen erinnert,. teils, dass die Oelproduktion aller Wahrscheinlichkeit nach in der Sommerzeit am größten ist, dass die Luftvacuolen nur eine Rolle bei den Planktonorganismen des Sommers spielen, dass die Formveränderungen im Frühling in der angegebenen Richtung gehen, dass die Balanceapparate länger werden, wird man leicht sehen, dass alle diese Modifikationen denselben Zweck erstreben: die Schwebfähigkeit der Organismen im Sommer zu vermehren, sie dem Leben im Wasser mit geringerem spezifischem Gewicht als im Winter anzupassen. Ich meine daher, dass man allein aus den Planktonuntersuchungen mit großer Wahrscheinlichkeit schließen kann, dass die Tragkraft des Wassers mit der Wärme abnimmt, ihr Minimum mit der höchsten Temperatur erreicht, im Herbst sich wieder steigert und dass im Januar, Februar ein Maximum eintritt.¹)

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1) Ich vermute, dass die Eigenbewegung der Planktonorganismen rücksichtlich der Richtung, in welcher sowohl die horizontale als auch die vertikale Bewegung vorgeht, gewöhnlich eine ganz untergeordnete Rolle spielt und im Vergleich mit der passiven Bewegung, die daraus hervorgeht, dass die Organismen von den Strömungen des Wassers fortgeführt werden, für nichts zu rechnen ist; bei dem Phytoplankton existiert überhaupt keine Eigenbewegung.

Verschiedene Beobachtungen und Betrachtungen über Phyto- und Zooplankton sowohl in der Natur als in Aquarien könnten darauf deuten, dass zwischen den zwei Arten Plankton der Fundamentalunterschied existiere, dass das Phytoplankton eher ein wenig leichter ist als das Wasser, wogegen das Zooplankton schwerer ist und daher geneigt zu Boden zu sinken. Dieses stimmt mit den von vielen gemachten Beobachtungen, dass die Hauptmasse des Phytoplankton

Es muss vorläufig unentschieden bleiben, ob nicht eine Tempo
variation hinsichtlich der Form innerhalb gewisser großer Abteilun
des Planktons, besonders Copepoden und Cyanophyceen, s
findet. Zeigt es sich, dass solches nicht der Fall ist, so wird es s
natürliche Erklärung darin finden, dass diese Gruppen in ihrer
und Luftproduktion ein Mittel haben, ihre Organisation der Tragk
anzupassen; dieses Mittel beruht indessen nicht auf einer Modifika
der äußeren Form und lässt sich folglich nicht durch eine mik
kopische Untersuchung, möglicherweise dagegen durch eine chemi
bestimmen.

Ganz natürlich entsteht also die Frage, welches Verlaufes und wel
Natur die physiologischen Prozesse sind, durch die die
erwähnten Planktonorganismen im Laufe des Jahres ihre Form
bilden. Man wird zu dem Resultate kommen, dass man es mit lo
sierten Wachstumsphänomenen zu thun hat; es ist nur das nähere Stud
dieser Phänomene, dass so bedeutende Schwierigkeiten darbietet. W
es möglich, die Versuchstiere wie die Schollen zu kennzeichnen
würde man schnell über diese Schwierigkeiten hinwegkommen;
dieses Verfahren sich hier leider nicht durchführen lässt und
Aquarienstudien bei diesen Untersuchungen durchaus verwerflich s
entstehen Schwierigkeiten, sobald man es versucht diese Verhält
ins Klare zu bringen. Am besten fängt man es gewiss mit den D
nien an; ich selbst habe meine Aufmerksamkeit wesentlich auf
Hylodaphnien gerichtet. Die Fragen, die sich hier zur Lösung
drängen, sind in erster Reihe folgende: Geht die Helmbildung
Frühling auf die Weise vor sich, dass die Tiere nach der Häu
mit einem längeren Helm und im Herbste nach jeder Häutung
einem kürzeren versehen werden, oder erleiden die Individuen se
keine solche Veränderung, wogegen es nur die Jungen sind, die
längeren Helmen als die Eltern geboren werden und zwar länge
später im Jahre die Geburt stattfindet. Nur teilweise bin ich imsta
diese Fragen zu beantworten. Dass es das Individuum selbst ist, de
Helm im Herbste nach jeder Häutung verkürzt wird, ist gewiss
man häufig Individuen in der Häutung antrifft innerhalb deren s
Schale man die neue angelegt findet; der Helm der neuen Schale

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in den alleroberstenWasserschichten und der Oberfläche des Wassers zu fi
ist, das Zooplankton dagegen erst 1 bis 2 Meter weiter unten. Alles Phytoplan
wird demgemäß infolge seiner eigenen Struktur, und ohne von äußeren Fakt
influiert zu werden, von selbst aufwärts zu den am stärksten beleuchteten Wa
schichten steigen, wo die Assimilationsbedingungen am besten sind; wäh
das Zooplankton sich weiter unten halten wird. Es scheint, als ob die Ei
bewegung bei diesen ihre wesentliche Bedeutung darin habe, dass sie das
allmähliche, äußerst langsame Hinabsinken, dass z. B. zwischen jeder Bewe
der Antennen bei Copepoden und Daphnien bemerkt werden kann, verhin

immer ein bedeutendes Stück kürzer, als der des alten, indem die vorderste Konturlinie ein beträchtliches Stück hinter der vordersten Konturlinie der alten Schale liegt. Schon 1895 hat Lundberg dieses nachgewiesen und ein Individuum abgezeichnet, dessen neues Hauptschild innerhalb des alten liegt. Inwiefern es dagegen in der Frühlingszeit das Individuum selbst ist, dessen Helm nach jeder Häutung länger wird, dafür habe ich keinen Beweis liefern können, obwohl ich es als sehr wahrscheinlich ansehe.

Bei der Untersuchung des Materials, das im Sommer 1898 alle 14 Tage im Frederiksborg Schlossee eingesammelt war, konnte ich die folgenden Verhältnisse konstatieren:

1. Die Jungen, welche die Hyalodaphnien in ihrem Brutraum hatten, waren mit bedeutend größeren Helmen versehen als die Muttertiere; dieselbe Wahrnehmung hat Burckhardt mitgeteilt.

2. Die Helme der Muttertiere im Juni-Juli waren bedeutend kürzer als die Helme der Muttertiere im September. Diese Beobachtung stimmt mit den von Zacharias und anderen gemachten überein.

3. Die Helme der Jungen, welche die Muttertiere des Frühlings in ihren Bruträumen hatten, waren viel länger als die, mit welchen die später Herbstbrut ausgesteuert war, und es schien, als ob der Unterschied zwischen der Länge der Helme bei dem Jungen und dem Muttertiere größer werde, je später im Jahre die Tiere eingesammelt waren.

Die Helmbildung bei den Hylodaphnien scheint also teils dadurch hervorzukommen, dass die Helme nach jeder Häutung länger werden, teils dadurch, dass die Jungen mit längeren Helmen geboren werden, als die Muttertiere.

Falls es gelingen wird, einen streng wissenschaftlichen Beweis dafür zu führen, dass die kurzhelmigen Muttertiere im Juni dieselben Individuen sind, die im September langhelmig auftreten, würde man sehen, dass dasselbe Muttertier im Juni kurzhelmige, im September langhelmige Junge gebäre. Man würde dann einen hübschen Beweis dafür haben, dass äussere Faktoren — in diesem Fall die abnehmende Tragkraft des Wassers — auf die äußere Form des Embryos influiren können. Es ist einleuchtend, dass diese Art Untersuchungen über die Temporalvariation bei älteren und jüngeren Tieren wohl die Reaktion der Organismen gegen die wechselnde Tragkraft des Wassers zeigen, uns aber nicht zu dem Verständnis der tiefer liegenden Motive dieser Formveränderungen leiten können.

Indem also die regelmäßig jährlich sinkende und steigende Tragkraft des Süßwassers in der Limnologie als ein für den Planktonorganismen sehr wichtiger ökologischer Faktor eingeführt wird, wäre wohl Ursache zu untersuchen, ob dieser Faktor nicht auch auf andere Weise dem Bau und dem Leben der Planktonorganismen seine Kennzeichen aufsetzt. Hauptsächlich möchte ich die Aufmerk-

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samkeit auf den Einfluss hinleiten, den dieser Faktor auf die
der Lebzeit dieser Planktonarten, auf den Zeitpunkt ihres Verschw
und den großen Unterschied in dem Bau der ausgeprägten Somm
Winterformen übt.

Regelmäßige Untersuchungen haben wie bekannt das Resu
geben, dass verschiedene Organismen zu ganz bestimmter Zeit a
Plankton verschwinden. Der Zeitpunkt, wo der große Umsc
dem Plankton, jedenfalls für unseren Breitengrad stattfindet, is
Frühlingszeit, wenn das Wasser eine Temperatur von 10° C. e

Die Diatomeen, die bis zu diesem Zeitpunkt die domini
gewesen, verschwinden von der Oberfläche, während gleichze
Cyanophyceen langsam in Art- und Individuenzahl zunehmen.
hin verschwinden die Diatomeen fast gänzlich, während die s
oder geringere Entwickelung des Cyanophyceeplanktons von s
verschiedenen Faktoren abhängig ist, die indessen mit dies
sammenhang nichts zu thun haben.

Auf einer Reise im Mai 1897, wo eine große Anzahl von g
Seen besucht wurden, konnte ich nachweisen, dass das Dia
plankton sich immer am längsten in den tieferen, kalten See
in den niedrigeren und wärmeren schnell den Cyanophycee
machte. Als ich dasselbe Jahr, im September, dieselben Seen be
konnte ich auf der anderen Seite konstatieren, dass die Di
immer zuerst in den kalten Seen dominierten, während die
phyceen noch in den niedrigen, wärmeren zahlreich waren.

Ich vermutete damals, dass diese Veränderungen in dem Ch
des Planktons und die bestimmten Zeitpunkte, da diese Veränd
stattfänden, hauptsächlich von der Temperatur abhängig seien.
Untersuchungen des Planktons des Fursees im Mai des fo
Jahres änderten jedoch meine Auffassung. Durch Vertikalfäng
noch mehr durch Horizontalfänge auf 5, 10, 15, 20, 30, 3
Wasser, konnte ich konstatieren, wie die Diatomeen mit der ste
Temperatur in den folgenden 4 Wochen immer tiefer und tie
unter sanken; noch 3 Wochen, nachdem die Diatomeen
ganz von der Oberfläche verschwunden waren, stand ein reich
tomeenplankton teilweise aus toten Pflanzen bestehend auf 2
Wasser. Ganz ebenso fand ich Mitte Juli vollständig totes mi
reich besetztes Dinobriumplankton auf 30 Meter Wasser sch
stehen; 3 Wochen früher bildeten die Dinobryen die Hauptma
Planktons in der Oberfläche der Seen. Es scheint mir aus die
obachtungen hervorzugehen, dass die sinkende Tragkraft de
flächewassers in erster Reihe Schuld daran ist, dass das Dia
plankton verschwindet, dazu gezwungen wird, die Wasser
welcher es nicht länger sein spezifisches Gewicht accomodiere
zu verlassen, indem die immer tieferen Wasserschichten mit d

genden Temperatur immer weniger Tragkraft erhalten, werden die Diatomeen immer tiefer hinunter gezwungen. Hierdurch wird indessen die sinkende Tragkraft des Wassers ganz natürlich eine der Todesursachen für das Diatomeenplankton des Frühlings, indem dieses von dem Oberflächewasser und dem Lichte fortgedrängt wird; in den tieferen Wasserschichten, bei weniger Licht, wird die Assimilation vermindert werden, die Vermehrung aufhören und das Resultat ein totes Plankton sein, das nur sehr langsam den Boden erreichen wird, oder möglicherweise, namentlich in tiefen Seen, sich auflösen wird, noch ehe dieses stattfindet.

Freilich habe ich, wie auch andere Untersucher, in einzelnen Seen im August Diatomeenmaxima gefunden, aber diese Maxima sind kleiner als die des April—Mai und müssen in unbekannten Lokalverhältnissen ihre Erklärung finden; ihr Erscheinen kann die hier über das überall und gesetzmäßig vorkommende Niedersinken der Diatomeen in der Frühlingszeit geltend gemachten Betrachtungen nicht umstoßen.

In der verschiedenen Tragkraft des Wassers zu den verschiedenen Jahreszeiten müssen wir also eine der Ursachen zu den Variationen in der Zusammensetzung des Planktons sehen. Vergleicht man die Diatomeen mit der Pflanzengruppe, die sie in der Zeit Mai—Oktober vorzugsweise ablösen, so wird der große Unterschied zwischen den zweifellos weit schwereren Kieselschalen der Diatomeen und den leichteren Cellulosenwänden der blaugrünen Algen ins Auge fallend sein. Außerdem sind die blaugrünen Algen mit Luftvacuolen ausgestattet, wobei selbstverständlich ihre Schwebfähigkeit im höchsten Grade vermehrt wird, während solche Vacuolen bei den Diatomeen ganz unbekannt sind. Stellt man auf der einen Seite die vorzugsweise typischen Planktonorganismen des Sommerhalbjahres, auf der anderen die des Winterhalbjahres und heftet seine Aufmerksamkeit auf diejenigen von diesen Organismen, die sich nicht das ganze Jahr finden, sondern nur entweder des Sommers oder des Winters, so wird es klar sein, dass alle die sogenannten Planktoncharaktere, alle die Bauverhältnisse, worauf die Schwebfähigkeit beruht, bei den typischen Sommerorganismen weit mehr hervortretend sind als bei den Winterorganismen. Als Beispiele der ersteren brauchen wir nur folgende hervorzuheben: *Bythotrephes*, *Leptodora*, *Holopedium*, *Notholca longispina*, *Schizocerca*, *Gastroschiza veciculosa*, *Synedra acus*, *Atheya*, *Rhizosolenia* und alle die *Croococcaseen* mit ihren Luftvacuolen; als Beispiele der letzteren *Notholca scapha* und *acuminata*, *Tintinidium*, *Codonella*, die *Melosiren* und *Fragilarien*, *Cymatopleua elliptica*, die jährlich regelmäßige Planktonorganisme in den kältesten Monaten (Februar—März) des Fursees sind, u. a. Das Verhältnis wird dann gleich deutlich hervortreten.

Es scheint daher einleuchtend zu sein, dass die für das Sommerhalbjahr typischen Planktonorganismen durch stärkere Balance-

apparate, Luftvacuolen etc. dazu angepasst sind in Wa
mit geringerer Tragkraft als das des Winterhalbjahre
schweben und also in Uebereinstimmung mit den Modifikati
welche die Arten, die das ganze Jahr hindurch leben, in der Son
zeit erleiden, modifiziert worden sind.

Es wird aus dem vorhergehenden hoffentlich hervorgehen,
die regelmäßig fallende und steigende Tragkraft des Wassers ein
Hauptursachen des starken Variierens ist, die alle den Plankton
nismen eigen ist, die ihr spezifisches Gewicht durch Formveränder
accomodieren. Wie bekannt sind eben dieselben Planktonorgani
Planktondaphnien, Bosminen, Anuräen u. a. zugleich einer h
tenden Lokalvariation unterworfen. Die ganze Hauptmasse
Planktonorganismen, die für die pelagische Region der großen
eigentümlich sind, finden sich, wie Zacharias u. A. auch bemerkt h
auch in den kleineren pflanzenbewachsenen Teichen und das Aus
der Art kann an den verschiedenen Orten sehr verschieden sein. U
sucht man, welche Bauverhältnisse der stärksten Lokalvariation u
worfen sind, so wird man finden, dass es beinahe immer di
genannten Planktoncharaktere sind, die, worauf die Sch
fähigkeit der Organismen beruht. Die verschiedenen Lokalrassen p
besonders in der Länge der Antennen (Bosminen), in dem Ve
der Konturen des Körpers (*Hyalodaphnia*, Bosminen), in der Läng
Dornen (zahlreiche Rädertiere) u. s. w. von einander abzuwe

Hierdurch wird man unwillkürlich auf die Vermutung ge
dass eine der Ursachen der starken Lokalvariation der Plankton
nismen in dem verschiedenen spezifischen Gewicht des
wassers an den verschiedenen Lokalitäten zu suchen
Diese ist bekanntlich von der Bodenbeschaffenheit, der Lokaltempe
des Ortes, die Menge der aufgelösten Stoffe in dem Wasser un
Natur dieser Stoffe abhängig. Die Ansprüche, die an die Schweb
keit einer Art gemacht werden, sind daher keineswegs überall
und es ist daher ganz natürlich, dass die Ausbildung der Schwebeapp
sich nach der Größe der Ansprüche richtet und an den verschie
Lokalitäten verschieden wird. Nach dem Bau des Planktons z
teilen, scheinen die großen, tiefen Seen die größten Anspr
zu machen; die Schwebeapparate sind nämlich immer stärke
wickelt bei den Individuen von der pelagischen Region der g
Seen, als bei denjenigen, die den kleineren Seen und Teichen
hören. Die Dornen sind zum Beispiel immer länger bei den Anur
und Triarthren der großen Seen und alle die eigentümlichen
stadien, wozu die Entwicklung bei den Daphnien, Hyalodap
und Bosminen (*D. galeata*, *H. Kahlbergensis*, *B. gibbera*, *the*
führt, finden sich gewöhnlich nicht in den kleinen Seen und sind
falls viel häufiger in den großen tiefen Seen.

Wahrscheinlicher Weise wird man indessen mit der Zeit noch weiter gehen können und in den Variationen des spezifischen Gewichts des Wassers sowohl zu verschiedenen Zeiten des Jahres an derselben Lokalität, als gleichzeitig an ganz verschiedenen Lokalitäten nicht nur eine Ursache der Variationen sehen, die alle die Organismen, die ihr spezifisches Gewicht durch Formveränderungen accomodieren, sondern auch einen artbildenden Faktor von großer Bedeutung. Um näher hierauf eingehen zu können, bedürfen wir jedoch einer näheren Kenntnis der Variationen des spezifischen Gewichts des Süßwassers, als wir augenblicklich besitzen.

Die hier gegebenen Mitteilungen über die Ursachen der temporalen und lokalen Variation der Planktonorganismen müssen notwendigerweise auf unsere Auffassung des Artsbegriffes innerhalb vieler der hier besprochenen Tiergruppen influieren, indem es einleuchtend sein wird, dass weite Grenzen für die Variation conditio sine qua non für die Planktonorganismen werden muss, die darauf angewiesen sind, ihr spezifisches Gewicht durch Veränderungen der äußeren Form nach der Tragkraft des Wassers zu accomodieren.

Wenn man sich in die Artbeschreibungen über die zahlreichen Planktondaphnien und Planktonrotiferen hineinarbeitet, wird man schnell darüber klar werden, dass die große Menge der Arten gerade auf die Planktoncharaktere, die äußere Form des Körpers, die Länge der Dornen und Antennen, die Hyalinität u. s. w. beschrieben sind.

Eine sehr umfassende und durchgreifende Reduktion ist unabweisbar notwendig; wie in der Einleitung hervorgehoben worden, ist die Reduktion auf mehreren Gebieten schon angefangen; so hat Weber ca. 30 Anuräaarten auf 4 zusammengezogen, Burckhardt ca. 40 Bosminenarten auf 2 u. s. w. Ganz ähnliche Reduktionen müssen innerhalb der Gattungen *Synchaeta*, *Dinobryum*, *Dileptus* und wahrscheinlich auch innerhalb gewisser Pflanzen-Gattungen (*Pediastrum*, *Staurastrum*) vorgenommen werden.

So weit mir bekannt, hat man die Reduktion angefangen, ohne dass man über die Ursachen der starken Varriierung dieser Planktonorganismen klar gewesen.

Sieht man auf die Periode zurück, wo die Planktonuntersucher sich veranlasst fühlten, eine ungeheure Anzahl Arten aufzustellen, so fragt man sich unwillkürlich, ob diese Periode wirklich ein notwendiges Durchgangsglied gewesen, ohne welches wir nicht zu der richtigeren Auffassung des Artsbegriffes gelangt wären, deren wir uns jetzt, dank den Untersuchungen Burckhardt's, Weber's, Richard's u. a. rühmen können. Die Forschungen jener Periode liefern jedenfalls einen sprechenden Beweis für den geringen wissenschaftlichen Wert, den derartige Studien haben, die nur die Verwandtschaftsbeziehungen der Tiere umfassen

und ihre Lebensart und die großen gemeinschaftlichen äußeren Fakt
ganz außer Acht lassen.

Nichts kann der exakten Naturwissenschaft ferner liegen als s
systematische Studien, die ausschließlich auf der Beschreibung gew
mehr oder weniger in die Augen springenden Bauverhältnissen
legt sind, ohne dass gleichzeitig Studien über deren Gebrauch un
Faktoren, die sie hervorgerufen, angelegt werden; die Systeme,
aus solchen Studien hervorgehen, sind nur leere Phantasien und sch
lich hat etwas mehr hemmend auf die exakte Naturwissenschaf
wirkt als diese systematischen Zwangsjacken, in welche man die
hineinzupressen versucht hat.

Wenn man, wie ich es oben versucht habe, eine physische
gründung des großen Variierungsvermögens der Planktonorgani
gegeben hat und diese verschiedenen Variierungsarten in direkter
bindung mit den physischen Verhältnissen des Süßwassers, mit
Temperatur, seinem spezifischen Gewicht und seiner chemischen
sammensetzung bringt, ist es unmöglich auf dem jetzigen Standp
der Limnologie einen ganz exakten, wissenschaftlichen Beweis für
Anschauung zu liefern.

Die schwebende Mikrofauna und Flora des Süßwassers is
Verein von Organismen, deren Lebensart von gewissen bestin
ökologischen Faktoren abhängig ist, deren Stärkegrad und Wirk
art wieder auf die verschiedenen Lokalitäten von Breitengrad,
des Terrains über dem Meere, Bodenverhältnissen u. s. w. abhängig
Kenntnis dieser Faktoren ist für das Verständnis des Baues un
Lebensart der Organismen durchaus notwendig, indem die ersteren
in zahlreichen Fällen zu den letzteren wie Ursache und Wirkung
halten. Da ein solcher Verein auf der anderen Seite aus zahlre
verschiedenartigen Organismen besteht, die jedes nach seiner
das Eingreifen der ökologischen Faktoren auf seine Weise beantw
sowie auch die einzelnen Organismen, unter übrigens verschiedena
Verhältnissen, den Einfluss des einzelnen Faktors auf verschi
Weise beantworten, ist eine genaue Kenntnis der Organismen a
für sich, der fundamentalen, durch zahllose Generationen ererbten
verhältnissen, der Elastizitätsgrenze u. s. w. ebenso unabweisba
wendig. Die Wechselwirkung zwischen dem Einfluss der äu
Faktoren und die verschiedene Weise auf welche jede einzeln
des Vereins, ja, jedes einzelne Individuum, diese Einwirkung
wortet, ist das wichtigste Moment in aller ökologischen Forschu

Wenn die Planktonuntersuchungen des Süßwassers bis je
wenige positive Resultate gegeben und die Anzahl der Theorie
die nüchterne Betrachtung größer scheint als die der Thatsachen
muss die Ursache hauptsächlich darin gesucht werden, dass ma
der ökologischen Natur der Aufgabe nicht hinlänglich bewus

wesen, dass man die Organismen als Ding an sich studiert und nicht gesucht hat, über die Bauverhältnisse, welche die Resultate anderer Faktoren beeinflussen, klar zu werden. Man hat bei den Planktonuntersuchungen die ökologischen Faktoren zu wenig berücksichtigt, ja, eigentlich nur die Temperatur untersucht und die meisten der anderen Faktoren liegen lassen.

Ich glaube das, was wir im Augenblicke nötig haben, sind regelmäßige 14tägige Untersuchungen, die denselben Tag in einem großen, tiefen See, in einem kleineren, in einem Moor und in einem ganz kleinen Teiche vorgenommen wurden; die Untersuchungen sollten das Plankton, das bestimmt und zum Teil abgezeichnet werden sollte, die Temperatur, die chemischen Verhältnisse, das spezifische Gewicht und den Luftinhalt des Wassers umfassen. Wenn dann die Resultate der physico-chemischen Untersuchungen mit den Zeichnungen und Präparaten des Planktons zusammengehalten würden, würde man vielleicht zu einem Verständnis gelangen können, sowohl was die Variationen und ihre Ursachen, die vielen biologischen Verhältnisse, rücksichtlich sowohl des ganzen Planktons als der Lebensart der einzelnen Componenten, betrifft.

Es war meine Absicht, nachdem ein kleineres süßwasserbiologisches Staatslaboratorium an dem Fursee, etwa 2 Meilen von Kopenhagen, errichtet worden, dahin zu streben, dass solche Untersuchungen vorgenommen wurden. Schon in $1^1/_2$ Jahren sind 14tägige Untersuchungen in 12 verschiedenen Süßwassergewässern im Gang gewesen; aber wie meine Vorgänger habe auch ich nur das Plankton und die Temperatur des Wassers berücksichtigt. Unter der Bearbeitung des Materials habe ich eingesehen, dass vieles in der Vorstellung, das nur rein theoretischer Natur war, wissenschaftlich bewiesen werden könnte, wenn gleichzeitig das spezifische Gewicht und andere Verhältnisse berücksichtigt würden, und ich habe deshalb die Publikation der schon recht umfassenden Untersuchungen vorläufig etwas aufgeschoben.

Eine Untersuchung, die gleichmäßige Rücksicht auf das Plankton und die physikalisch-chemischen Verhältnisse des Wassers nimmt, ist, wenn sie gleichzeitig in 4 Gewässern vorgenommen werden soll, mit großen Schwierigkeiten verbunden, und ob es mir gelingen wird, sie ohne Lücken durchzuführen, kann von Verhältnissen abhängen, über welche man unmöglich Herr sein kann; die Untersuchung würde sich wahrscheinlich auch besser in einem Lande mit größeren und tieferen Seen als die unsrigen ausführen lassen.

Meiner Meinung nach sind die Planktonuntersuchungen im Augenblicke an einen Punkt gekommen, über welchen hinaus sie nicht können, ohne dass eine solche Untersuchung aufgenommen wird; diese müsste denn Aufklärung aller der Verhältnisse geben, über welche wir uns nun streiten: die Wan-

1909.

derungen des Planktons in den 24 Stunden, die Ursachen seines
mäßigen Verschwindens und Erstehens zu den verschiedenen Zeite
Jahres, die vielen eigentümlichen Verhältnisse in dem Bau und Leb
einzelnen Planktonorganismen, die Variation und ihre Ursachen u.

Falls diese Auffassung Sympathie gewinnen möchte, könnten
liche Untersuchungen vielleicht von anderen biologischen Sta
vorgenommen werden, die über größere Wasserareale gebiete
die, welche ich anwenden kann. Mit dieser Möglichkeit vor
ist diese kleine Untersuchung publiziert worden. —

Es ist mir eine willkommene Pflicht, dem Hydrographen der
schen Ingolfexpedition cand. mag. **Martin Kundsen**, mit de
über viele, diese Untersuchungen betreffende physische Verhältnisse
konferieren können, meinen besten Dank zu sagen.

Süfswasserbiologisches Laboratorium am Fursee
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THE ALGÆ OF THE BIRKET QARUN, EGYPT.

PHYTOPLANKTON FROM THE ALBERT NYANZA.

③

BY G. S. WEST, M.A., D.Sc., F.L.S.

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WILLIAMS AND NORGATE.
1909.

THE ALGÆ OF THE BIRKET QARUN, EGYPT.

By G. S. West, M.A., D.Sc., F.L.S.

(Plate 498.)

The Algæ comprised in the present paper were collected by Dr. W. A. Cunnington during the recent expedition (1907) conducted by himself and Mr. C. L. Boulenger to the Birket Qarun, a lake in the Fayûm Province of Egypt. Little is known of the Algæ of Egypt, and the only records I can find are a few by Hansgirg and Zahlbruckner.[*]

The Birket Qarun is a shallow lake some twenty-five miles in length by five or six miles in breadth. Dr. Cunnington states[†] that "it is, however, only a remnant of the historic Lake Moeris, which was many times greater." The lake still communicates with the Nile by the Bahr Yusef, a channel over two hundred miles long. The water is brackish, with a density a little above that of fresh water (specific gravity = 1008·2 at 60° F.). The total amount of dissolved salts is about 1·1 per cent. Dr. Cunnington writes that, "since the lake is so shallow, the water is subject to considerable changes in temperature, corresponding to the differences of the air-temperature between night and day, which are often pronounced. Recorded temperatures show a maximum of 94·2° F. in very shallow water close to the shore about 2 p.m., and a minimum of 54·8° F. as a surface reading in the early morning. A difference of temperature of as much as 8·8° F. was also observed between the surface water and that at a depth of six feet."

Algæ were collected from the shores of the lake (principally from stones), from ponds, swamps, and stagnant pools near the shores, and from the inlets. A number of plankton-collections were also made. The total number of Algæ obtained, *viz.* sixty-six species, is not very great, a fact which must be attributed to the brackish character of the water from which most of the collections were made. As one would expect, the *Chlorophyceæ* are poorly represented (only fourteen species or 21·2 per cent.), whereas the *Myxophyceæ* and *Bacillarieæ* are very prominent, the former being represented by nineteen species (or 28·8 per cent. of the total) and the latter by thirty-two species[‡] (or 48·5 per cent.).

One of the most interesting features of the collections was the occurrence of *Polysiphonia utricularis* Zan. and a form of *Enteromorpha plumosa* Kütz., both of which are typically marine Algæ. The presence of a species of *Polysiphonia* in the lake is quite on

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[*] *Vide* Ann. k. k. Naturhist. Hofmus. Wien, 1904, pp. 402, 403, &c.

[†] Cunnington in Proc. Zool. Soc. June, 1908, p. 3.

[‡] It is probable that at least ten more species should be added to the Diatoms, as there are some which I have not been able to satisfactorily identify.

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a level with the occurrence of the Anthomedusan discovere
the expedition. The majority of the Algæ collected were bra
forms, the only freshwater species being obtained from nea
mouth of the Wady.

THE LITTORAL ALGA-FLORA.—Included in this section a
those Algæ attached to stones on the shores of the lake,
floating in shallow water near the shore or thrown up o
beach by the waves, and also those scraped from the bottom
boat used by the expedition.

The common Alga attached to the stones of the shore
form of *Entermorpha plumosa* Kütz., which showed conside
variability in its characters. Amongst it were numerous Dia
especially *Nitzschia plana* W. Sm., a variety of *N. Sigma* W.
and *Navicula avenacea* Bréb., the latter frequently forming a
yellow-brown stratum. *Gyrosigma elongatum* (W. Sm.)
West was also conspicuously present, and numerous threa
Spirulina subtilissima Kütz. occurred in the diatomaceous str
which covered some of the stones.

Attached to the bottom of the boat were quantities of *C*
phora fracta (Dillw.) Hass. more or less loaded with the epip
Rhoicosphenia curvata (Kütz.) Grun. and *Navicula avenacea*
Among the dense clusters of branches were quantities of *Me*
Borreri Grev. and *Bacillaria paradoxa* Gmel. A soft, dull
stratum of *Phormidium ambiguum* Gom. covered those part
occupied by the *Cladophora*, and many Diatoms found a ho
this stratum.

Close to the shore, in the inlets, *Ulothrix flacca* (Dillw.)
was not uncommon, and *Polysiphonia utricularis* Zan. was
floating in shallow water, mixed with filaments of *Enterom*
plumosa Kütz. Epiphytic on the *Polysiphonia* were large nu
of *Cocconeis Placentula* Ehrenb. and *Asterocystis smara*
(Reinsch) Forti.

Thrown up on the beach were numerous pieces of the
stratum of *Spirulina subtilissima* Kütz., doubtless torn fro
stones by the wave-action.

The stagnant pools around the lake were also brackis
character, and from them and a drying-up salt-lagoon a nu
of the *Oscillatoriaceæ* were collected. Chief among these
Phormidium Corium Gom., *Oscillatoria proboscidea* Gom., *O.*
Kütz. var. *neapolitana* (Kütz.) Gom., and a form of *Spir*
laxissima G. S. West. Spore-bearing filaments of *Nodu*
spumigena Mertens also occurred among the *Oscillatoriaceæ*
one pool contained a large quantity of a species of *Euglena*.

THE PLANKTON (in April, 1907) consisted for the most p
immense numbers of Entomostraca and Rotifers. Among
teeming animal life was a somewhat meagre phytoplankton
prising only three species of Diatoms. These were *Campylod*
Clypeus Ehrenb., *Melosira Borreri* Grev., and *Nitzschia*
(Kütz.) Grun. The two former were fairly abundant, bu
last-named was very rare.

SWAMPY PONDS AT THE MOUTH OF WADY (fresh water).

swampy ponds near the mouth of the Wady were much less brackish than most of the others, and these ponds yielded some very interesting *Chlorophyceæ.* Two species of *Spirogyra* were obtained with zygospores, *S. decimina* (Müll.) Kütz. (the most frequent species of the genus in tropical and subtropical countries) and *S. dubia* Kütz., and among them were fine fruiting specimens of *Zygnema chalybeosporum* Hansg. with characteristic dark blue spores. A thin monogynous form of *Vaucheria sessilis* (Vauch.) DC. also occurred in quantity, and with it a few fruiting filaments of *Œdogonium intermedium* Wittr.

Among these *Chlorophyceæ* were a number of interesting blue-green Algæ, the most conspicuous of which were two species of *Cylindrospermum* (of which one—*Cyl. indentatum*—is new), *Anabæna oscillarioides* var. *tenuis* Lemm., *Katagnymene palustris* sp. n., and several species of *Phormidium* and *Oscillatoria.*

Systematic Account of the Species.

In the following list the Diatoms are to some extent incomplete. This is particularly the case with the genus *Nitzschia,* species of which always occur abundantly in brackish water. I have met with the greatest difficulty in attempting to identify some of these Egyptian species of *Nitzschia,* especially the smaller sigmoid forms, and some of them have consequently been omitted from the present list. Of the *Myxophyceæ,* the most interesting are *Cylindrospermum indentatum, Katagnymene palustris,* and *Asterocystis smaragdina.* The numbers after the localities are those attached to Dr. Cunnington's collections.

Rhodophyceæ.

1. *Polysiphonia utricularis* Zan. Floating in shallow water, Island Camp (no. 451).

Chlorophyceæ.

2. *Œdogonium intermedium* Wittr. in Wittr. & Nordst. Alg. Exsic. 1886, no. 178; Hirn in Acta Soc. Sci. Fennicæ, xxvii. 1900, p. 94, t. 5. f. 31.

Forma oosporis oogonia non complentibus.

Crass. fil.	17–19 μ;	altit.	3–3½-plo major.
,, oogon.	41–46 μ;	,,	42–46 μ.
,, oospor.	35–38 μ;	,,	35–37 μ.
,, cell. antherid.	18 μ;	,,	6 μ.

Swampy ponds near mouth of Wady (no. 389).

3. *Ulothrix flacca* (Dillw.) Thur.; Hazen in Mem. Torr. Bot. Club, xi. 1902, p. 155, t. 20, f. 7–9. Crass. fil. 20–29 μ. Inlet of lake, close to shore at Promontory Camp (no. 440).

4. *U. tenerrima* Kütz. Crass. fil. 8–9 μ. Coating the stems of grasses in about one foot of water in swamp near east end of Birket Qarun.

5. *Enteromorpha plumosa* Kütz. Crass. fil. 52-107 μ; cell. 8–14 μ. On rocks in shallow water (no. 454). Also other forms, on stones and floating (nos. 426 and 451).

6. *Cladophora fracta* (Dillw.) Hass. Crass. fil. prim. 98–
ram. 34–45 μ. Attached to the bottom of the boat (no. 421)
obtained floating in the river "El Wady" (no. 397).

7. *Vaucheria sessilis* (Vauch.) DC. A rather slender
gynous form. Crass. fil. 44–48 μ; long. oogon. 92–98 μ, la
75 μ. Swampy ponds near mouth of Wady (no. 389).

8. *Zygnema chalybeospermum* Hansg. in Hedwigia,
p. 257; in Notarisia, 1889, p. 679. Crass. cell. veget. 28–
diam. zygosp. 42–47 μ. Swampy ponds near mouth of
(nos. 389 and 393). This interesting species of *Zygnema* oc
in abundant conjugation, and the ripe zygospores were of
blue colour. The Egyptian plants were very slightly large
those originally described by Hansgirg from Bohemia, bu
otherwise exactly similar.

9. *Spirogyra decimina* (Müll.) Kütz. With the pre
species (no. 389).

10. *S. dubia* Kütz. Tab. Phyc. v. t. 24, f. iv; Rabenh.
Europ. Algar. iii. 1868, p. 243. Crass. cell. veget. 48 μ;
zygosp. 66–82 μ. Scarce among the preceding species (no
I am somewhat doubtful with regard to this determination,
specimens were not good, and it is not unlikely that Kü
"species" should be relegated to some other. Each cell pos
two very broad spirals, with irregular margins.

11. *Spirogyra* sp. (sterile). Cells 1–2 times as long
diameter, with three broad spirals furnished with large pyre
Crass. cell. veget. 78–82 μ. Rather scarce in swampy pond
Wady (no. 389).

12. *Closterium Leibleinii* Kütz. Amongst the pre
species (no. 389).

13. *Ankistrodesmus falcatus* (Corda) Ralfs var. *spirilli*
G. S. West. In swampy ponds near mouth of Wady (no. 3

14. *A. setigerus* (Schröder) G. S. West, Treat. Brit. F
Algæ, 1904, p. 224. [*Reinschiella ? setigera* Schröder in
Deutsch. Bot. Ges. xv. 1897, p. 492, t. 25, f. 4; *Schröderia s*
(Schr.) Lemm. in Hedwigia, xxxvii. 1898, p. 311.]

Forma minor; long. cum spin. 42 μ; lat. max. 3 μ. Wi
preceding species (no. 389). In general aspect the spe
were very like British forms of *A. setigerus*, but they w
smaller dimensions than any previously observed examples
setigerous species. The cells possessed one parietal chlo
with no trace of a pyrenoid, but the presence or absence of
noids is a very variable feature in the genus *Ankistrodesm*
is largely dependent upon nutrition.

15. *Tribonema bombycina* (Ag.) Derb. & Sol. forma
(Wille) G. S. West. Crass. cell. 7–8 μ. Rather rare an
species of *Spirogyra* in ponds near mouth of Wady (n. 389)

BACILLARIEÆ.

16. *Melosira Borreri* Grev. General through Birket
and its surroundings, occurring abundantly on the shores

the swampy pools of the littoral region, and also in the plankton. It was present in almost all of Dr. Cunnington's collections.

17. *M. varians* Ag. In swampy ponds (no. 389).

18. *M. granulata* (Ehrenb.) Ralfs. In swampy ponds (no. 389). On stones in shallow water (no. 430).

19. *Stephanodiscus Astræa* (Ehrenb.) Grun. In swampy ponds (no. 389).

20. *Diatoma elongatum* Ag. On stones in shallow water (no. 430).

21. *Fragilaria* sp. Valve view lanceolate with obtuse poles; striæ short and coarse, 7 in 10 μ. Length of valve 17–22 μ, breadth 5 μ. In swampy ponds (no. 389).

22. *Synedra radians* (Kütz.) Grun. In shallow water (no. 430).

23. *Cocconeis Placentula* Ehrenb. Attached to the bottom of boat (no. 421); also on stones in shallow water (no. 430).

24. *Navicula gracilis* Kütz. In algal matrix attached to bottom of boat (no. 421), and in shallow water (nos. 430 and 454).

25. *N. producta* W. Sm. In swampy ponds (no. 389), and in an algal scum on surface of stagnant pool (no. 471).

26. *N. avenacea* Bréb.; Cleve Synops. Navic. Diatoms, ii. 1895, p. 15. [*Schizonema Smithii* (Ag.) V. H.] On stones in shallow water (no. 430), and also on mud in a drying-up salt-lagoon (no. 439). The colonies of this diatom in some cases formed a dense yellow-brown stratum.

27. *Gyrosigma elongatum* (W. Sm.). On stones in shallow water (nos. 430 and 448); also in stagnant pool (no. 471).

28. *Amphiprora paludosa* W. Sm. In great abundance on the mud of a drying-up salt-lagoon (no. 439).

29. *Mastogloia exigua* Lewis. On stones in shallow water (no. 430).

30. *Gomphonema parvula* Kütz. In swampy ponds (no. 389).

31. *Rhoicosphenia curvata* (Kütz.) Grun. In swampy ponds (no. 389), and on stones in shallow water (nos. 426 and 430).

Var. *marina* (W. Sm.) Van Heurck. On bottom of boat (no. 421).

32. *Cocconema gracile* (Rabenh.) G. S. West. On stones in shallow water (no. 430).

33. *Amphora salina* W. Sm. On rocks in shallow water (no. 454).

34. *A. coffæiformis* (Ag.) Kütz. Small stagnant pool (no. 471).

35. *Rhopalodia gibba* (Kütz.) O. Müll. On stones in shallow water (no. 430).

36. *R. gibberula* (Ehrenb.) O. Müll. In swampy ponds (no. 389), and in algal scum of stagnant pool (no. 471).

37. *Bacillaria paradoxa* Gmel. Among *Cladophora* on bottom of boat (no. 421).

38. *Nitzschia Palea* (Kütz.) Grun. In swampy ponds (no. 389) and on the bottom of the boat (no. 422); also rare in the plankton (no. 414).

39. *N. communis* Rabenh. In swampy ponds (no. 389).

40. *N. punctata* (W. Sm.) Grun. On bottom of boat (no.

41. *N. fasciculata* Grun. On rocks in shallow water (no.

42. *N. plana* W. Sm. On stones in shallow water (no. 4

43. *N. Sigma* W. Sm. var. *sigmatella* Grun. In the m
drying-up salt-lagoon (no. 439).

44. *N. obtusa* W. Sm. var. *scalpelliformis* Grun. On roc
shallow water (no. 454).

45. *Surirella ovalis* Bréb. In swampy ponds (no. 389).

46. *S. striatula* Turp. In stagnant pool (no. 471).

47. *Campylodiscus Clypeus* Ehrenb. Abundant in the
plankton (nos. 414, 423, and 428); also among other Diato
stones in shallow water (nos. 430 and 448).

MYXOPHYCEÆ.

48. *Anabæna oscillarioides* Bory var. *tenuis* Lemm. in K
gamenfl. Mark Brandenburg, Bd. iii. Heft 2, 1907, p. 189.
cell. veget. 2·8–3 μ; long. spor. 10–17 μ, lat. 4·3–6 μ. In sw
ponds (no. 389).

49. *Nodularia spumigena* Mertens. In ponds near mou
Wady (no. 393); forming part of scum on surface of sta
pool (no. 471; with spores).

50. *Cylindrospermum musicola* Kütz. In swampy
(no. 389).

51. **Cylindrospermum indentatum,** sp. n. Trich
flexuosa in thallo gelatinoso parvo et irregulari (2–3·5 mm.
associata; cellulis vegetativis subquadratis vel quadrato-ob
(diametro ¾–1½-plo longioribus), cytioplasmate granulato; h
cystis elliptico oblongis; sporis singulis, ovato-ellipticis, polo
cellulas vegetativas late rotundato, altero juxta heteroc
truncatis et leviter concavis, episporio glabro. Crass. cell.
4·5–5 μ; long. spor. 34–36 μ, lat. 17·5–18·5 μ; long. hete
9–11·5 μ, lat 5·8-6·5 μ. (Figs. 8–10.)

In ponds near mouth of Wady (n. 393).

This species is well characterized by its elliptic-ovate
with dissimilar extremities. The pole next the vegetati
ment is broadly rounded, while that next the terminal het
is abruptly truncated and slightly hollowed.

It is perhaps nearest to *C. licheniforme* (Bory) Kütz., but
in its larger vegetative cells, in the peculiar form of its
and in its aquatic habit.

52. **Katagnymene palustris,** sp. n. Trichomata s
inter algas varias consociata, leviter et gracile curvata, su
et crassa; parte apicali subtruncata et cellula apicali co
cellulis brevissimis discoideis; vagina mucosa lata achroa e
irregulari. Crass. cell. 28 μ; long. cell. 2·8–3 μ. (Fig. 17.

In swampy ponds near mouth of Wady (no. 389).

The genus *Katagnymene* was described by Lemmerm
1899 (in Abh. Nat. Ver. Bremen, Bd. xvi. Heft 2) to inclu
marine species collected in the plankton of the Pacific Oce

The Egyptian plants were associated with *Zygnema ch* *spermum* Hansg., *Vaucheria sessilis* (Vauch.) DC., *Cylindrospermum indentatum* nob., *Anabæna oscillarioides* var. *tenuis* Lemm., and other Algæ. I have seen but two filaments of it, and the peculiar nature of the mucous sheath precludes its inclusion in any genus other than *Katagnymene.* This sheath was quite colourless, and although rather wide was most irregular in outline. It reached a maximum diameter of about 74 μ.

53. *Phormidium ambiguum* Gom. Attached to bottom of boat (no. 422).

54. *P. Corium* (Ag.) Gom. In drying-up salt-lagoon (nos. 438 and 439).

55. *P. fragile* (Menegh.) Gom. In swampy ponds (no. 389).

56. *P. tenue* (Menegh.) Gom. In ponds near mouth of Wady (no. 393).

57. *Oscillatoria proboscidea* Gom. Crass. trich. 12·5–13 μ. In algal scum on surface of stagnant pool (no. 471).

58. *O. formosa* Bory. In ponds near mouth of Wady (no. 389).

59. *O. animalis* Ag. With the preceding species (no. 389).

60. *O. brevis* Kütz. var. *neapolitana* (Kütz.) Gom. Monogr. des Oscillar. 1893, p. 249. The trichomes were all subacute and uncinate, and the curious "inflated cells" were very numerous. Crass. trich. 7·5–8 μ. (Fig. 11.) Associated with *O. proboscidea* (no. 471).

61. *O. amphibia* Ag. With the preceding species (no. 471).

Forma *contorta.* Forma trichomatibus subbrevibus multe contortis; cellulis diametro 1¾–2-plo longioribus. Crass. trich. 2 μ. In ponds near mouth of Wady (no. 393).

This form occurred amongst the gelatinous matrix of *Cylindrospermum indentatum*, *Nodularia spumigena*, and *Spirulina major*, forming closely coiled filaments of no great length, which resembled irregular coils of rope.

62. *Spirulina major* Kütz. Crass. trich. 1–1·2 μ; diam. spir. 2·5 μ; anfractibus 3·2 μ inter se distantibus. In ponds near mouth of Wady (no. 393).

63. *S. subtilissima* Kütz. Crass. trich. 0·7 μ; diam. spir. 2·8 μ; anfractibus 1·7–1·8 μ inter se distantibus. On stones in shallow water (nos. 426 and 430). In a pure stratum, thrown up on beach (no. 444) and floating in shallow water (no. 451). Also on surface of stagnant pool (no. 471).

64. *S. laxissima* G. S. West, "Alg. Third Tanganyika Exped." Journ. Linn. Soc. Bot. xxxviii. 1907, p. 178, t. 9, f. 6. Forma trichomata in spiram regularem diametro 5–8 μ contorta, anfractibus 15–17 μ inter se distantibus. Crass. trich. 0·7 μ; long. tot. trich. 19–45 μ. (Figs. 2–4.) In drying-up salt-lagoon (nos. 438 and 439).

The Egyptian form differs from the Tanganyika specimens in the slightly greater width of the spirals, which are also very slightly closer together.

65. *Asterocystis smaragdina* (Reinsch) Forti, Syll. Myxophycearum, 1907, p. 691. [*Callonema smaragdinum* Reinsch, Contrib.

Alg. et Fung. 1867, i. p. 41, t. 16. *Allogonium smi*
(Reinsch) Hansg.]

Var. *palustris* Hansg. Prodr. Algenfl. Böhm. 1888
(sub *Allogonium*). Forma cellulis quadratis, oblongis, ve
cylindricis (diam. usque ad 3-plo longioribus), polis
vel truncatis; filis solitariis, non ramosis (ut visis);
firmo et achroo. Diam. cell. 4·5–8 μ; long. cell. 8-24
12-16.)

Epiphytic on *Polysiphonia utricularis*, floating i
water (no. 451).

This variety was described from Bohemia ("in stag

66. *Chroococcus turgidus* (Kütz.) Näg. In algal sc
face of stagnant pool (no. 471).

PHYTOPLANKTON FROM THE ALBERT N

By G. S. West, M.A., D.Sc., F.L.S.

In July, 1907, Mr. R. T. Leiper, M.B., Helminthol
London School of Tropical Medicine, who accompanied
expedition despatched to Uganda by the Egyptian Surv
ment, collected in the Albert Nyanza a sample of pl
also a tube of material obtained in thirty feet of wa
were forwarded to me for examination by Dr. Cunn
the results afford an interesting comparison with
plankton of the other large African lakes.

Altogether forty-eight species were observed in th
collection, none of which could be described as domina
two-thirds of these species also occurred in the coll
near the bottom. *Melosira granulata*, *Synedra Cu*
Glenodinium pulvisculus, and certain species of *Tetr*
Scenedesmus were fairly common, but most of the ot
tuents were infrequent. The tow-nettings contained
quantity of decaying organic matter, mostly of veget
and in this respect they resembled Dr. Cunnington's co
Victoria Nyanza. Entomostraca were not uncommo
a number of sponge spicules. A quantity of *Chama*
fervicola was noticed on some decaying filaments of
Rhizoclonium. *Staurastrum leptocladum* forma *afri*
astrum Boryanum var. *rugulosum*, *Synedra Cunning*
form of *Volvox aureus* were of particular interest. A
Microcystis and a large Diatom of the genus *Vanhe*
been described as new.

The following is a complete list of the species obse

Chlorophyceæ.—*Mougeotia* sp. (sterile; with lar
31 μ in diameter), *Euastrum spicatum* Turn., *Staura*
cladum Nordst. forma *africana* G. S. West, *St. gracil*
G. S. West var. *biradiatum* W. & G. S. West, *St.*

Schmidle (a somewhat reduced form, 5-radiate; long. 33 μ, lat. c. proc. 52–56 μ), *Volvox aureus* Ehrenb. (a form), *Pediastrum simplex* Meyen, *P. duplex* Meyen, and var. *reticulatum* Lagerh., *P. Boryanum* (Turp.) Menegh., and var. *rugulosum* G. S. West, *Cœlastrum cambricum* Arch., *C. reticulatum* (Dang.) Senn, *Scenedesmus acutiformis* Schröder var. *brasiliensis* (Bohlin) W. & G. S. West, *S. denticulatus* Lagerh., *S. obliquus* (Turp.) Kütz., *S. quadricauda* (Turp.) Bréb., and var. *Opoliensis* (Richter) W. & G. S. West, *Ankistrodesmus convolutus* (Rabenh.) G. S. West, *A. falcatus* (Corda) Ralfs var. *acicularis* (A. Br.) G. S. West, *Kirchneriella obesa* W. & G. S. West, *Tetraëdron minimum* (A. Br.) Hansg., *T. trigonum* (Näg.) Hansg., *T. tetragonum* (Näg.) Hansg., and forma *arthrodesmiforme*, *T. regulare* Kütz. (various forms), *T. enorme* (Ralfs) Hansg., *Glœocystis vesiculosa* Näg.

HETEROKONTÆ. — *Ophiocytium capitatum* Wolle var. *longispinum* Lemm.

BACILLARIEÆ.—*Melosira nyassensis* O. Müll., *M. granulata* Ralfs, *Cyclotella Kützingiana* Chauvin, *Synedra Ulna* (Nitzsch) Ehrenb., *S. Cunningtonii* G. S. West, *Cocconeis Placentula* Ehrenb., *Navicula acrosphæria* (Bréb.) Kütz., *Stauroneis Phœnicenteron* (Nitzsch) Ehrenb., *Vanheurckia africana*, sp. n., *Gyrosigma distortum* (W. Sm.) Cleve var. *Parkeri* (Harrison) Cleve, *Gomphonema africanum* G. S. West, *Epithemia turgida* (Ehrenb.) Kütz., *Surirella Engleri* O. Müll. var. *constricta* O. Müll. (long. 209 μ; lat. max. 44 μ), *Cymatopleura Solea* W. Sm.

MYXOPHYCEÆ.—*Lyngbya contorta* Lemm., *Oscillatoria princeps* Vauch., *O. tenuis* Ag., *O. formosa* Bory, *Merismopedia elegans* A. Br. (colonies with upwards of 3000 cells), *Microcystis densa*, sp. n.

PERIDINIEÆ.—*Glenodinium pulvisculus* (Ehrenb.) Stein, *Peridinium inconspicuum* Lemm.

FLAGELLATA.—*Phacus pleuronectes* Nitzsch.

Of the above forty-eight species, twenty-four (or 50 per cent.) are *Chlorophyceæ*, fourteen (or 29·1 per cent.) are *Bacillarieæ*, and only six (or 12·5 per cent.) *Myxophyceæ*.

The following require special mention:—

VOLVOX AUREUS Ehrenb. The specimens differed in several particulars from the European forms of this species. The number of daughter-colonies developed within the mother-colony were fewer than is usually the case, and their growth is such that they become ellipsoid or ovoid by compression before being set free. I hope to deal specially with this form at a subsequent date.

TETRAEDRON TETRAGONUM (Näg.) Hansg. forma ARTHRODESMIFORME. Cellula in aspectu generali ad speciem *Arthrodesmi* accedens; in parte mediana subconstricta, angulis in spinos elongatos subparallelos productis. Lat. cell. sine spin. 16–22 μ; lat. max. cum spin. 56 μ. (Fig. 1.)

Vanheurckia africana, sp. n. Cellula ut in visa asp valvulari rhomboideo-lanceolata, polis obtusis; nodulo cen paullo elongato; striis validis et conspicuis, iis transversis 1 10 *μ*, iis longitudinalibus 9 in 10 *μ*; long. valv. 196 *μ*; lat. 44 *μ*. (Fig. 18.)

This large and handsome species has the same outward as *V. rhomboides* (Ehrenb.) Bréb., but the valves are of cons ably larger dimensions, and both the longitudinal and trans striations are much coarser than in any known form of species.

Lyngbya contorta Lemm. in Forschungsber. Biol. Stat. vi. 1898, p. 202, t. 5, f. 10–13. The filaments were 1·6-2 diameter, and twisted into fairly close spirals. (Fig. 5*a* an I am in considerable doubt as to its correct identification, and examples tend to confirm my previous remarks,[*] and also suggestions of Ostenfeld,[†] that the limnetic species of *Lyn* require complete revision. The specimens from the Albert Ny do not agree with *L. circumcreta*, differing especially in narrower and more extended character of the spirals. Oste (*l. c.* p. 335) seems to me to be in error in placing both *L. con* and *L. circumcreta* under *L. Lagerheimii*. Two apparently tinct species occur in the large African lakes, which I previously recorded as *L. Lagerheimii* and *L. circumcreta* freely admit that I may be wrong in both determinations, b am convinced that the plants I have so recorded are not f of one species.

Microcystis densa, sp. n. Cellulæ globosæ, læte ærugin 4 *μ* crassæ, *pseudovacuol.* absentæ, in coloniis permagnis (1400 *μ*, lat. 415 *μ*) densissime confertis; coloniis elongatis et cylindricis, polis rotundatis versus attenuatis. (Figs. 6–7.)

This species stands near to *M. pulverea* (Wood) Migula in crowded nature of its cells and in the absence of "pseudovacuo (gas vacuoles), but the cells are rather larger and the colonie vastly greater dimensions.

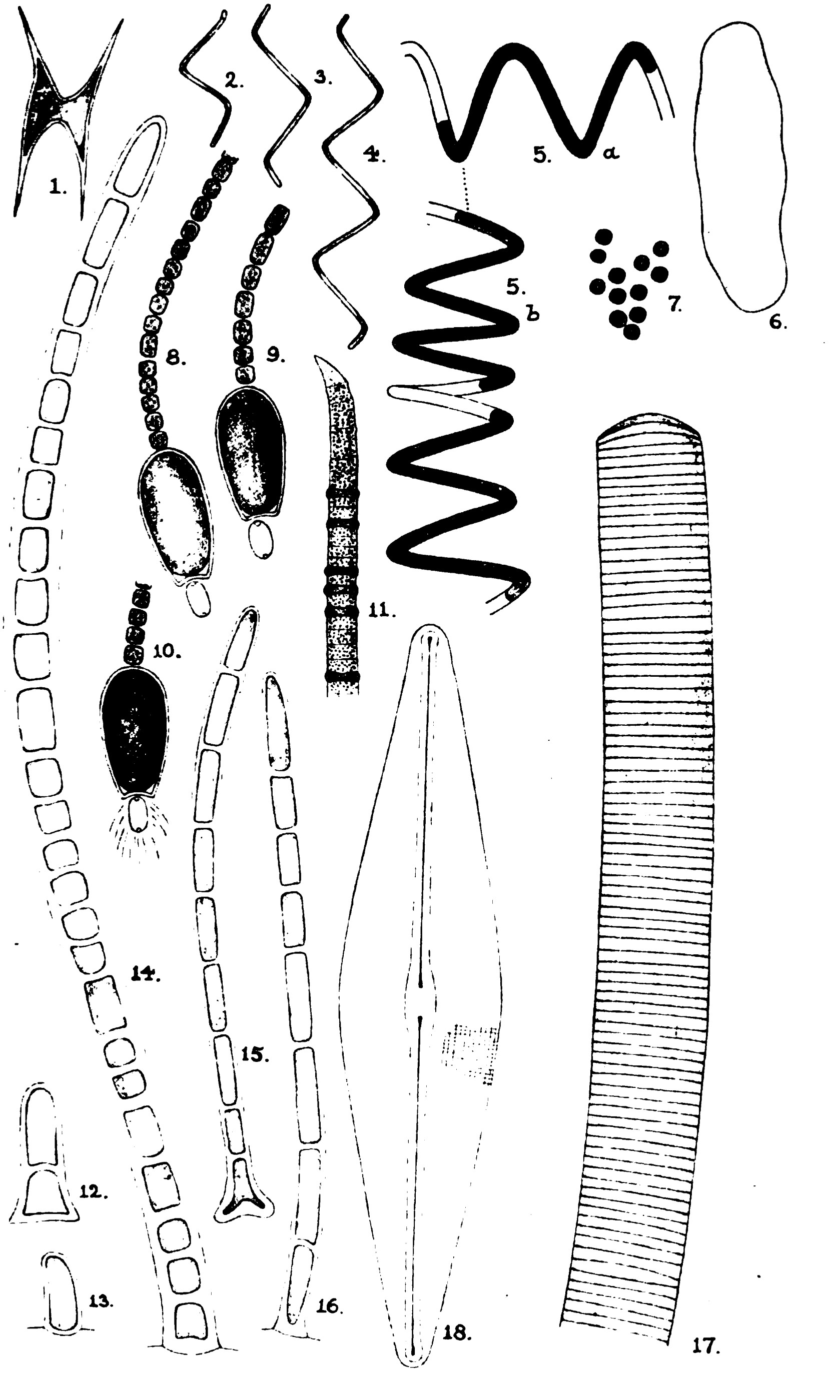
Description of Plate 498.

Fig. 1. *Tetraëdron tetragonum* (Näg.) Hansg. forma *arthrodesmiforme*. × 2–4. *Spirulina laxissima* G. S. West forma, × 1000. 5 *a* and *b*. *Lyngbya torta* Lemm., × 1000. 6–7. *Microcystis densa*, sp. n. 6. Entire colony, × 7. A few of the cells, × 500. 8–10. *Cylindrospermum indentatum*, sp. n., × 11. *Oscillatoria brevis* Kütz. var. *neapolitana* (Kütz.) Gom., × 500. 1 *Asterocystis smaragdina* (Reinsch) Forti. All × 500. Fig. 13 is the ea stage in the formation of a new plant; fig. 14 is one of the adult filam 17. *Katagnymene palustris*, sp. n., × 500. 18. *Vanheurckia africana*, s × 500. The striations are only indicated on a small area of the valve.

---

[*] G. S. West in Journ. Linn. Soc. Bot. xxxviii. 1907, p. 175.

[†] C. H. Ostenfeld, "Phytoplankton aus dem Victoria Nyanza," Engl. Jahrbüch. v. 1908, p. 335 (c. fig. 2).



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THE JOURNAL

OF

THE LINNEAN SOCIETY.

(BOTANY.)

The Algæ of the Yan Yean Reservoir, Victoria: a Biological and Œcological Study.

By G. S. West, M.A., D.Sc., F.L.S., Lecturer on Botany in the University of Birmingham.

(Plates 1–6 and 10 Text-figures.)

[Read 18th June, 1908.]

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INTRODUCTION.

About the middle of October, 1904, I received from Mr. A. D. Hardy, F.L.S., of the Lands Department, Melbourne, two slides of Algæ from the Yan Yean Reservoir, and their inspection revealed such a number of interesting species that I asked permission to examine more of the material. The sample had been obtained in February, 1904, about two hundred yards from the shore, and from the nature of the species observed I felt certain that the Algæ of the Yan Yean Reservoir would be well worth investigation.

Shortly afterwards, in response to my suggestion, Mr. Hardy very kindly consented to obtain for me periodical collections from this large sheet of water, and I have to tender him my best thanks for one of the most interesting and instructive series of collections I have yet examined. Mr. Hardy forwarded me, according to detailed instruction, samples of the plankton taken by boat at regular monthly intervals for thirteen months, in addition to samples from the weedy margin of the reservoir taken with the same regularity, and others from various parts of the drainage area. The value of these collections is greatly enhanced by records of the temperature, both of air and water, by remarks upon the meteorological conditions prevailing at the time of collecting and between the dates of collection, as well as by sundry information which has a bearing upon the distribution of Algæ in this district of Victoria.

The Yan Yean Reservoir *, which has a superficial area of about 1460 acres, furnishes part of the water-supply for the city of Melbourne, distant about 25 miles. Some of the water comes by an open aqueduct from the Toorourong Reservoir, a smaller body of water of 36 acres, supplied by small streams which, with their tributaries, drain a large portion of both the southern and northern slopes of the range of mountains dividing Victoria into a northern drier and a southern well-watered territory †. The formation of the reservoir began in 1853 by the construction of an embankment, five-eighths of a mile in length and 30 feet in height, to join the ends of low hills which form the south-westerly extremity of the catchment basin—an area of 4500 acres. The reservoir was completed in 1857, but only since 1883 has the main water-supply been along the aqueduct from the Toorourong Reservoir. The intake by this aqueduct is roughly about six times the amount received from the rainfall in the catchment basin ‡.

Much of the Toorourong supply is similarly obtained along an open channel,

---

* It may be of interest to know that the name "Yan Yean" is recorded as having been that of an Australian aboriginal chief, who signed the Batman Treaty (June 11, 1835), and means "boyish" or a "bachelor."

† A chart compiled by Mr. Hardy from data furnished by Mr. P. Baracchi, the Government Astronomer, clearly shows a wide difference in the rainfall of the northern as contrasted with the southern district. Prof. J. W. Gregory, however, does not recognize the dividing range, and from geological evidence states that, "in spite of geographers and biologists," the Great Dividing Range is a misleading geographical myth.

‡ The intake by aqueduct in 1903 was 5,984,000,000 gallons, and by rainfall in catchment basin was 1,021,953,000 gallons. In 1904 the figures were respectively 7,447,949,000 gallons and 1,125,326,000 gallons.

about 8 miles in length, partly natural and partly paved, which comes from the Wallaby Creek Weir, a dam at almost a thousand feet greater altitude. The water of the Wallaby Creek Weir is in a like manner partly brought along an open paved channel from a still higher dam, the Silver Creek Weir, distant about 5 miles.

A constant supply of water along the aqueduct to the Yan Yean Reservoir is assured by the dams at Toorourong, Wallaby Creek, and Silver Creek. The catchment area for the two upper dams is 11,500 acres, and the outflow streams find their way into King Parrot Creek. The catchment area of the Toorourong Reservoir is 10,500 acres, the water-supply from which is additional to that along the open channel from the upper dams, and the outflow of the reservoir is the east branch of the Plenty River.

The following records of the rainfall, although incomplete, indicate a great increase in the amount registered corresponding to a relatively small increase in altitude :—

		Yan Yean. Altit. 400 ft.	*Toorourong.* Altit. 736 ft.	*Wallaby Creek.* Altit. 1717 ft.	*Silver Creek.* Altit. 1740 ft.
		Catchment area 4500 acres.	Catchment area 10,500 acres.	Catchment area 11,500 acres.	
Registered rainfall	1903.	29·03 ins.	36·85 ins.	51·7 ins.	No records.
	1904.	26·67 „	33·75 „	56·39 „	
	1905.	29·63 „	—	—	

As the chief part of the water-supply of the Yan Yean Reservoir (some six-sevenths of the total volume) comes along the aqueduct from the Toorourong Reservoir, which is in turn largely supplied from the Wallaby Creek dam, it is therefore derived from a large area in which the rainfall is considerably greater than that which actually obtains in the Yan Yean catchment basin itself.

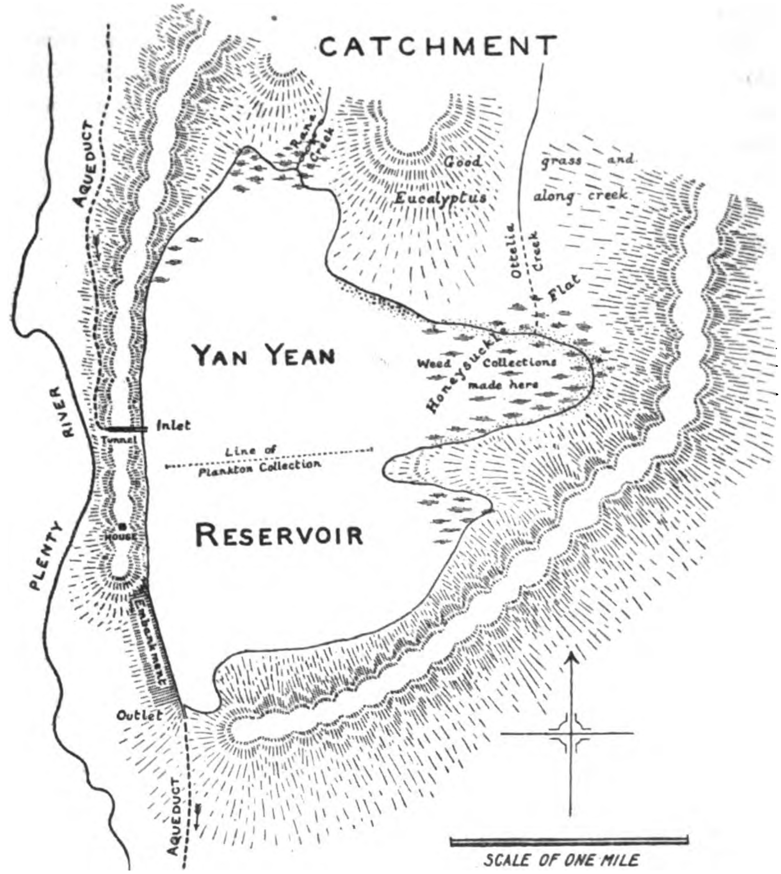
The full capacity of the reservoir is 6,400,000,000 gallons, and its average depth is a little over 24 feet.

The geological formations of the entire drainage area are Silurian and Granitic. The more distant supplies come from the granite of Mt. Disappointment (2630 feet), about 8 miles to the north, and the rest of the drainage is on outcrops of Silurian.

Some of the banks of the Yan Yean Reservoir are natural, others are stone-faced from below the low-level to above the high-water mark, and an embankment forms an artificial boundary at the south-west corner. The shores when gently sloping are weedy, but away from the margin the lake is fairly free from evident vegetation.

Mr. Hardy has furnished me with much information concerning the spermatophytic and pteridophytic flora of the district. He records *Prunella vulgaris*, *Bulbine bulbosa*, *Burchardia umbellata*, *Arthropodium strictum*, *Craspedia richea*, *Leptorhynchus tenuifolius*, *Drosera Menziesii*, *D. Whittakeri*, *Stackhousia linariifolia*, *Glycene clandestina*, *Eryngium vesiculosum*, *Stylidium graminiifolium*, *Aster* sp., *Helichrysum* sp., *Ranunculus lappaceus*, *R. aquatilis*, *Diuris sulphurea*, *D. maculata*, etc., as growing on the grassy slopes draining into the reservoir and sheltered by the pine plantation which almost surrounds it. On the remoter parts of these slopes a few native Australian shrubs and trees occur, such as *Exocarpus cupressiformis*, *Banksia marginata*, *Casuarina*

Fig. 1.



The Yan Yean Reservoir, showing the aqueduct from the Toorourong Reservoir, and the lower, swampy parts of the two creeks (Rana Creek and Ottelia Creek) in the catchment basin. The line of plankton collection is also indicated.

quadrivalvis, *Acacia melanoxylon*, *Eucalyptus globulus*, *E. citriodora*, *Hakea laurina*, etc. Mr. Hardy states that the few recent (Post-pliocene) deposits of the catchment area of the Yan Yean carry only stunted growths, and that the low-lying part of the Silurian country to the north is sparsely timbered with several kinds of *Eucalyptus*, but that the timber improves with increasing altitude, growing taller and straighter, while the undergrowth becomes denser. The gullies are rich in shrubs, and the creeks afford moisture for numerous ferns. Of the large tree-ferns, *Dicksonia Billardieri* and *Alsophila australis* are common, the brown trunks often being draped with *Hymenophyllum*. The shade-loving *Pteris incisa* and *P. tremula* are conspicuous, but *Pteris aquilina* is everywhere, while along the aqueduct between Wallaby and Silver Creeks *Gleichenia circinata* and species of *Lomaria* are abundant.

At the weedy margins of the Yan Yean the marsh plants are chiefly the rush-like *Heleocharis sphacelata* (the flowering shoots of which attain in places a length of eight feet), *Arundo Phragmites* (only in the N.W. corner), *Triglochin striata*, *Myriophyllum variifolium*, *Limnanthemum exaltatum*, and *Potamogeton natans*, the two latter almost monopolising small areas. Further out are *Potamogeton obtusus*, *Triglochin procera*, *Myriophyllum elatinoides*, *Vallisneria spiralis*, and a species of *Nitella* (about two feet in length). Flourishing among these larger plants there is an abundant littoral Alga-flora which will be considered in its relation to the phytoplankton.

Mr. Hardy's enthusiasm, combined with a sound knowledge of the requirements of the work he was so kindly undertaking for me, caused him to visit, at considerable trouble and inconvenience to himself, the different parts of the entire drainage area. Not only was this done for the collection of Algæ, but also for obtaining any information that might bear upon their distribution. He procured me samples of plankton from the Toorourong Reservoir, and from the dams at both Wallaby and Silver Creeks, for comparison with the Yan Yean plankton. In addition, he made a number of collections from different parts of the drainage area, especially in the vicinity of the two swampy inlets of the Yan Yean to which he has given the names of 'Rana Creek' and 'Ottelia Creek,' the former owing to the congregation of multitudes of frogs, and the latter by reason of the presence of *Ottelia ovalifolia* in most of the pools.

The present paper is divided into several chapters, of which the first three deal respectively with the phytoplankton of the Yan Yean Reservoir, the littoral Alga-flora, and the general Alga-flora of the drainage area. The Algæ of the entire area, and the different parts of it, are then discussed in their various relationships; the more important and interesting species are dealt with systematically; and lastly, attention is drawn to the peculiarities of the Alga-flora of Australasian freshwaters.

I. THE PHYTOPLANKTON.

General Notice.

The reports upon phytoplankton from the southern hemisphere are so far very few. The large lakes of Central Africa have been somewhat extensively explored *, but apart from these investigations the only other records are a few scanty notes on the limnetic flora of Lake Wakatipu, New Zealand †. The present report is therefore of great interest, not only because it constitutes the first plankton-investigation of Australian freshwaters, but also on account of the extended period over which the collections were made.

Detailed periodical investigations of plankton have been carried out in several parts of Europe, notably by Lemmermann, Schröder, Zacharias, and Volk in Germany, by Wesenberg-Lund in Denmark, by Chodat and Bachmann in Switzerland, and by Huitfeldt-Kaas in Norway. Other less comprehensive studies have been made of the lakes of Sweden, Austria, and the British Islands. Some excellent work has also been done in the United States, but more especially on the zooplankton.

The collections from the Yan Yean Reservoir show very clearly that the Australian plankton, when more fully investigated, will afford an interesting comparison with that of the temperate and subtropical regions of the northern hemisphere.

The plankton was collected in all cases along an easterly course, about a mile in length, across the middle of the lake, any part of the littoral region where weeds came near the surface being avoided. Mr. Hardy forwarded me two samples of each collection, one preserved in 3 per cent. formalin and the other in 4 per cent. potassium acetate (containing a trace of copper acetate).

In the tabulated account which follows, only those Algæ have been recorded which were fixed in the living condition. Empty individuals, obviously dead at the time of preservation, have been omitted.

The METEOROLOGICAL OBSERVATIONS accompanying the collections consisted of barometric and thermometric records, together with notes on the general condition of the weather at the times of collection and during the intervals between one collection and the next.

The *barometric readings* were taken by Mr. Wilson, the Resident Inspector, at 4 P.M. on the dates of collection, at which time a start was made to obtain the material, the temperatures being taken during the process of collection. The barometer was contained in a house about 100 feet above the surface of the lake, which is about 400 feet above sea-level, and the monthly readings indicate a remarkable uniformity of atmospheric pressure extending over a period of thirteen months.

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* W. Schmidle, in Engl. Bot. Jahrb. xxvi. (1898); xxxii. (1903); xxxiii. (1904). G. S. West, in Journ. Linn. Soc., Bot. xxxviii. (1907).

† E. Lemmermann, in Abh. Nat. Ver. Bremen, Bd. xvi. Heft 2 (1899), pp. 338, 339.

Date.	Temp. of water.	Temp. of air.	Barometer.	Remarks on Weather.
1905. Feb. 4th ...	17·8° C. (=64° F.)	31·1° C. (=88° F.)	746·7 mm. (=29·4 ins.)	Fine warm day, with continuous sunshine; light wind causing a rippling of surface. Considerable rain two days previously.
Mar. 4th ...	18·5° C. (=65° F.)	22·8° C. (=73° F.)	749·2 mm. (=29·5 ins.)	Fine and sunny; light breeze ruffling the surface. No recent rain.
April 1st ...	17·8° C. (=64° F.)	13·3° C. (=56° F.)	758·1 mm. (=29·85 ins.)	Calm and cloudy; cold after frost; light wind gradually increasing in strength, and surface becoming choppy.
May 6th ...	18·9° C. (=66° F.)	22·8° C. (=73° F.)	749·2 mm. (=29·5 ins.)	Calm and sunny; surface smooth.
June 3rd ...	12·2° C. (=54° F.)	12·2° C. (=54° F.)	749·2 mm. (=29·5 ins.)	Cold and cloudy; surface smooth. A week's rain before the collection.
July 1st ...	10·0° C. (=50° F.)	12·2° C. (=54° F.)	749·2 mm. (=29·5 ins.)	Cold and sunny; wind strong and surface choppy. Rain preceding day.
Aug. 5th ...	10·0° C. (=50° F.)	15·0° C. (=59° F.)	751·7 mm. (=29·6 ins.)	Sunny, with strong N. wind; surface rough. Should have been the coldest month, but the N. wind made a relatively warm day. Water risen 2 feet owing to rains, and increased its area by about 30 acres.
Sept. 2nd ...	10·0° C. (=50° F.)	14·4° C. (=58° F.)	749·2 mm. (=29·5 ins.)	Dull and cloudy; surface at first smooth, but becoming ruffled with increasing wind. Preceding week very wet, and depth of water further increased.
Oct. 7th ...	12·2° C. (=54° F.)	11·1° C. (=52° F.)	776·1 mm. (=30·56 ins.)	Sunny, with light S. wind; surface rippled. Reservoir very full; preceding month with frequent rains and fall of snow.
Nov. 4th ...	15·0° C. (=59° F.)	15·6° C. (=60° F.)	744·1 mm. (=29·3 ins.)	Surface slightly rippled by W. wind. Copious rainfall during preceding month; reservoir very full, and vegetation of shores almost invisible.
Dec. 2nd ...	20·0° C. (=68° F.)	15·6° C. (=60° F.)	746·7 mm. (=29·4 ins.)	Storm of hail and rain immediately preceding the collection; preceding week warm, ending in tropical showers.
1906. Jan. 6th ...	23·3° C. (=74° F.)	35·6° C. (=96° F.)	751·7 mm. (=29·6 ins.)	Calm and hot; reservoir still full. Weather hot and dry during most of preceding month.
Feb. 10th ...	24·4° C. (=76° F.)	30·0° C.* (=86° F.)	749·2 mm. (=29·5 ins.)	Calm and hot; level of water falling slowly. Preceding month calm and hot.

* During the collection the temperature fell from 30·0° C. (86° F.) to 22·2° C. (72° F).

The *temperatures of the water* are surface temperatures taken at a depth of from six to twelve inches. The lowest recorded temperature was 10° C. (50° F.), which occurred on each of the three dates July 1st, Aug. 5th, and Sept. 2nd, 1905; the highest was 24·4° C. (76° F.) on Feb. 10th, 1906.

The *air-temperatures* naturally show a greater range of variation, from 11·1° C. (52° F.) on Oct. 7th, 1905, to 35·6° C. (96° F.) on Jan. 6th, 1906. On June 3rd, 1905, the temperatures of the air and water exactly coincided at 12·2° C. (54° F.).

In the accompanying chart (text-fig. 2) the thermometric observations are plotted out, and they show at a glance the smaller rise or fall of the temperature of the water corresponding to a greater rise or fall of the air-temperature. It will be noticed that in no instance does the recorded air-temperature fall below the minimum temperature of the water *. The

Fig. 2.

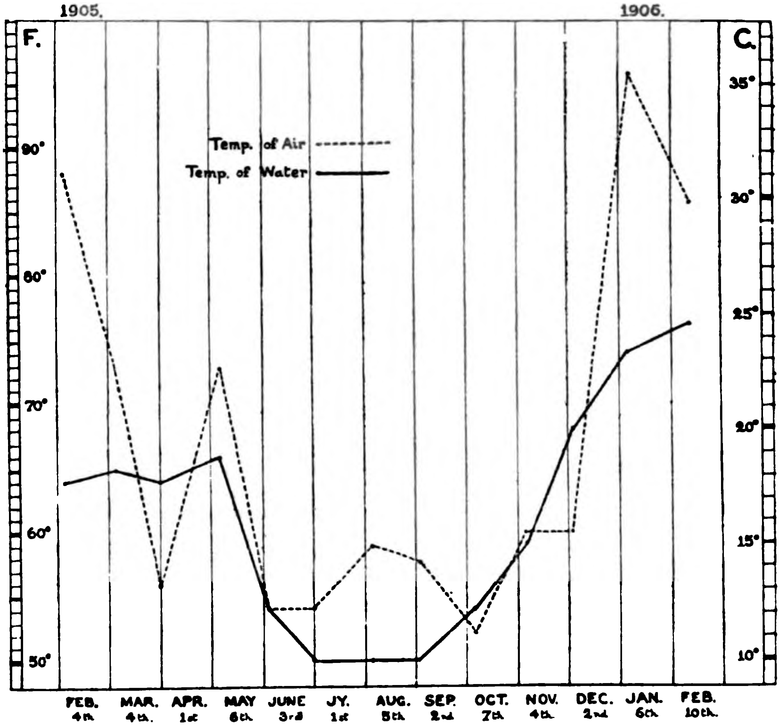

Chart showing the variations in the temperature of air and water at the Yan Yean Reservoir, Feb. 1905 to Feb. 1906.

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* This feature is due to the almost entire absence of prolonged frosts, and is not shown in a similar comparative series of observations relating to any lake in the temperate and more northerly parts of Europe, in which the record of air-temperatures would several times reach a minimum considerably lower than any shown in a correlated record of water-temperatures.

comparative coolness of the water relative to the maximum air-temperature is most probably due to the supply conveyed along the aqueduct from the dams fed by streams which drain the mountain slopes to the north. The constant influx of this cool water may also account for the slowness of the changes in temperature of the water following on considerable variations in the atmospheric temperature.

There is an average daily evaporation from the Yan Yean Reservoir of 1,197,000 gallons, or $\frac{1}{13}$ inch of the depth.

A chemical analysis of the Yan Yean water-supply furnished to Mr. Hardy by the Metropolitan Board of Works of Melbourne shows a somewhat unusual proportion of chlorides, but otherwise the data are in no way remarkable.

Chemical Analysis of Melbourne Water Supply.
[For year 1905 only.]
In parts per 1,000,000.

Where taken.	Date, 1905.	Total solid matter.	Free Ammonia.	Albuminoid Ammonia.	Oxygen consumed.	Chlorine.
Silver Creek	Nov. 1	53	0·010	0·064	2·80	14·0
Wallaby Creek	May 1	58	0·018	0·152	11·35	15·0
Toorourong Reservoir	May 1	78	0·038	0·212	9·35	17·5
	Nov. 1	74	0·028	0·184	5·30	19·0
Yan Yean Inlet	May 1	70	0·038	0·166	9·05	18·0
Yan Yean Outlet	May 1	62	0·027	0·119	3·25	21·0
	Nov. 1	68	0·010	0·138	3·45	20·0

The Yan Yean Reservoir has a very rich phytoplankton, which reaches its greatest development in March and April, at the time when the Crustacea are least evident. The collections were made over precisely the same course on each occasion, and only from the open water away from the shore. I have regarded the material as true plankton as contrasted with the benthos which occurs at the weedy shores. The minimum amount of phytoplankton occurs in September and October, in which months it is almost wanting.

The most striking feature of the plankton is the richness of its Desmid-flora, in this respect offering a close comparison with the plankton of many of the lakes of the western British areas. This Desmid-flora is of exceptional interest because of the Australian types abundantly contained in it. The Desmids are dominant from about the middle of February to the end of April, reaching their greatest maximum in March and April, The most abundant and noteworthy forms are discussed in connection with t periodicity (consult page 19).

I ascribe the richness of this Desmid-flora to the nature of the geolog formations upon which the Yan Yean Reservoir is situated, and from wh it derives its water-supply. During the past sixteen years I have ma detailed study of the Desmidiaceæ, and, so far as Western Europe is concer the distribution of characteristic types, and also the richness of the Des flora, has a close relationship with the geological formations of the drai areas which may be under consideration[*]. The really rich Desmid-fl are only found on the Older Palæozoic and Precambrian formations[†]. phytoplankton of lakes in these areas is much richer in the Desmidiaceæ t that of lakes situated on newer formations. Even the lakes of a Carbonife area are poor as regards their Desmid-flora, unless part of the drainag derived from outcrops of Silurian or of still older rocks. Outcrops of Ign material also materially increase the richness of the Desmid-flora of a dist

It seems probable that one of the primary factors which brings about richness of the Desmid-flora is the hardness and durability of the rocks stituting the older strata. The resistance of these rocks to subaërial de dation is due in a large measure to their antiquity; in other words, to great compression they have been subjected to owing to weight of overly strata, and to those movements in the earth's crust which have produ folding and contortion. The direct outcome of this action has been the duction of mountainous regions which are suitable for the formation of p bogs; and wherever these conditions have been realized, there the Des flourish very well. They unquestionably thrive in suitable situations wh the water contains small quantities of humic and other organic acids; b seems probable that other chemical considerations play no small part in t distribution, otherwise it is difficult to account for those types which are a rently limited to the bogs and lakes of areas older than the Carboniferou

With the one exception of *Melosira granulata*, the Diatoms are not conspicuous. The complete absence of *Fragilaria* and *Asterionella* is a n worthy feature[‡]. The comparative scarcity of Diatoms and the absenc some of the widely distributed plankton-genera is to be attributed to relatively high temperature of the water, which was not below 10° C. at time of collection on any occasion during the thirteen months over which observations were made. Many of the European plankton-diatoms at their maximum development at a temperature 5°–7° C. lower than the minimum temperature recorded for the water of the Yan Yean [*].

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[*] This relationship is at present being worked out in detail in the British Islands, w we are particularly fortunate in having almost a complete succession of geological strat

[†] W. West & G. S. West, "The Alga-flora of Yorkshire," Trans. Yorks. Nat. Unio (1901) p. 5; G. S. West, Treatise Brit. Freshw. Algæ (1904), p. 6.

[‡] The genera *Fragilaria* and *Asterionella* were entirely absent from the plankton o large African lakes in which the mean temperature of the surface-water was above 2 *Cf.* G. S. West in Journ. Linn. Soc., Bot. xxxviii. (1907) pp. 84 and 88.

The great scarcity of Blue-green Algæ (Myxophyceæ) is one of the most remarkable peculiarities of the Yan Yean plankton. These Algæ play a most important part in the summer plankton of the shallower European lakes, in which the water attains a temperature no higher than that attained by the water of the Yan Yean, and, moreover, falls considerably lower in the winter months. They likewise constitute a large part of the plankton of the lakes of tropical Africa [†], in which the surface-temperature of the water maintains an average equal to the highest summer temperature of the Yan Yean. As the Yan Yean Reservoir occupies an intermediate position between the lowland lakes of temperate regions and the lakes of the tropics with regard to its climatological conditions, but lacks the blue-green plankton-algæ so characteristic of both, it is possible that the chemical composition of the water has a direct influence on the growth of the blue-green plankton-algæ. In the light of this suggestion it is interesting to recall the fact that the Myxophyceæ constitute the principal vegetation of hot-springs [‡], in which the water may contain a great diversity of mineral constituents in solution.

Few Flagellates occurred in the Yan Yean plankton. *Mallomonas* and *Trachelomonas* were both absent, but two forms of *Dinobryon* were not at all uncommon.

MONTHLY STATEMENT OF PLANKTON FROM FEB. 1905 TO FEB. 1906.

Feb. 4th, 1905.—Desmids dominant, and a few scattered Crustacea (Copepods, *Bosmina*, and Nauplii). *Melosira granulata* and *Dinobryon cylindricum* var. *divergens* both common.

Mar. 4th, 1905.—Desmid-flora exceedingly rich; dominance due to great abundance of *Staurastrum corniculatum* and its var. *spinigerum*, *S. assurgens* var. *victoriense*, *S. longiradiatum*, *S. leptacanthum*, *S. muticum* var. *victoriense*, *Micrasterias Hardyi*, *Cosmarium capitulum* var. *australe*, *C. Hardyi*, *C. contractum*, and *C. contortum* forma *trigona*. Intermixed with the numerous Desmids were a few members of the Protococcoideæ, chiefly *Glœocystis gigas* and *Sphærocystis Schroeteri*. A few scattered Crustacea occurred, with many Nauplii. *Melosira granulata* was abundant, and the Flagellate *Dinobryon cylindricum*, with its var. *divergens*, was also very common.

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[*] *Vide* C. H. Ostenfeld & C. Wesenberg-Lund in Proc. Roy. Soc. Edinb. xxv. part xii. (1906) p. 1109.

[†] W. Schmidle, in Engl. Bot. Jahrb. xxxi. (1902); xxxiii. (1904). *Cf.* also G. S. West, *l. c.* pp. 89 and 90 (34 species of Blue-green Algæ recorded for the plankton of the three lakes Nyasa, Victoria Nyanza, and Tanganyika).

[‡] W. H. Weed, "Formation of Travertine and Siliceous Sinter by the Vegetation of Hot Springs," Report U.S. Geol. Survey, 1887–88; G. S. West, "On some Algæ from Hot Springs," Journ. Bot., July 1902.

April 1st, 1905.—Desmids still dominant, the most abundant species being *Cosmarium Hardyi*; others in great abundance were *Staurastrum leptacanthum*, *S. longiradiatum*, *S. corniculatum* and its var. *spinigerum*, and *Micrasterias Hardyi*. *Peridinium Volzii* var. *australe* was not uncommon, but *Dinobryon* was rare. *Melosira granulata* still abundant, mostly with short filaments possessing the curious spines of var. *spinosa*, Schröder*. *Chroococcus limneticus* var. *subsalsus* was not infrequent; and the Crustacea were beginning to be more conspicuous.

May 6th, 1905.—Reduction in quantity of Desmids and also in number of species. The smaller species had almost vanished, but *Cosmarium Hardyi* and *Staurastrum leptacanthum* were not uncommon, and *Micrasterias Hardyi* was still abundant. *Melosira granulata* still fairly common, and the individuals of *Peridinium Volzii* var. *australe* are much larger, with thicker walls and more marked areolation of the plates. No *Dinobryon* was observed. The Crustacea now very evident, forming a relatively large amount of the plankton.

June 3rd, 1905.—Crustacea dominant. Few Desmids present, only odd specimens of *Micrasterias Hardyi* and a few other large species. Very little *Melosira granulata*. Quantity of *Sphærocystis Schroeteri*.

July 1st, 1905.—Crustacea dominant, and owing to mass of individuals actual bulk of plankton is increasing. *Micrasterias Hardyi* the only Desmid. *Sphærocystis Schroeteri* quite common. *Melosira granulata* distinctly scarce.

Aug. 5th, 1905.—This month the plankton reached its greatest bulk owing to the enormous abundance of Crustacea (*Daphnia*, *Bosmina*, *Cyclops*, and other genera). Phytoplankton almost wanting. *Melosira granulata* was rare, and a few specimens of *Micrasterias Hardyi*, *Staurastrum victoriense*, and *Desmidium Swartzii* were observed.

Sept. 2nd, 1905.—Crustacea still paramount, and actual bulk of plankton little less than in August. Desmids represented by a few isolated specimens of *Micrasterias Hardyi*. *Melosira granulata* rare, but the Diatoms were further represented by a few fine specimens of *Surirella robusta* var. *splendida*. The plankton contained quantities of the pollen-grains of Pines.

Oct. 7th, 1905.—Relative bulk of plankton only about half that obtained in August. Great diminution in numbers of Crustacea, and a plentiful admixture of Nauplii among the adults. Desmids rare. Very little *Melosira granulata*, but a few specimens of *Navicula bicapitata* could always be found. *Tetraspora lacustris* quite common, the colonies appearing to be young, some of them having rather a tough integument.

Nov. 4th, 1905.—The dominant constituents were Chlorophyceæ and Diatoms, but plenty of Copepods, *Bosmina*, and Nauplii were still present. Of the Chlorophyceæ, *Tetraspora lacustris* was most conspicuously abundant, the colonies being more expanded than in the preceding month and the mucous investment practically invisible. *Micrasterias Hardyi*, *Eudorina elegans*, and *Botryococcus Braunii* were all fairly abundant, and a few of the smaller Desmids were rare. *Volvox aureus* present in small quantity. Fragmentary filaments of small species of *Zygnema* and *Spirogyra* were not uncommon. Of the Diatoms, *Melosira granulata* was the most abundant, the filaments varying much in relative thickness. *Navicula viridis* was not at all uncommon, and next in order of frequency were *Navicula bicapitata* and *Surirella robusta* var. *splendida*. *Dinobryon cylindricum*, with its var. *divergens*, had again appeared in fair abundance.

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* B. Schröder in Ber. Deutsch. Bot. Ges. xv. (1897) p. 373, t. 17. f. 3.

Dec. 2nd, 1905.—Chlorophyceæ and Diatoms conspicuous, but Nauplii could almost be said to be dominant. *Micrasterias Hardyi* and *Volvox aureus* were the most conspicuous of the Chlorophyceæ, and *Melosira granulata* much the most abundant of the Diatoms. Schröder's spiny variety of the latter species was greatly in evidence. Few small Desmids. *Dinobryon cylindricum* var. *divergens* present in great abundance. A feature of this December plankton was the presence of an immense multitude of long unicellular hairs of vegetable origin, and most probably brought into the lake by the heavy rains of the preceding month. It has not been possible to determine from which plant these hairs were derived.

Jan. 6th, 1906.—The dominant constituents of the plankton were three species, one of each of the groups Bacillarieæ, Flagellata, and Chlorophyceæ. *Melosira granulata* and *Dinobryon cylindricum* var. *divergens* were present in great abundance, and *Pediastrum duplex* var. *reticulatum* occurred in almost as great a profusion. Many of the filaments of *Melosira granulata* had developed auxospores. The most interesting Diatom was *Rhizosolenia morsa*, which was quite common. *Crucigenia* and *Oocystis* make their first appearance after the colder weather. The smaller Desmids show signs of becoming quite common, but *Micrasterias Hardyi* was less abundant.

Feb. 10th, 1906.—The dominant feature was the quantity of *Melosira granulata*, with a plentiful sprinkling of thick filaments derived from the auxospores of the preceding month. *Dinobryon cylindricum* var. *divergens* occurred in quantity, but the colonies were mostly broken up. Larger Desmids were common (e. g., *Cosmarium Hardyi*, *Micrasterias Hardyi*, *Staurastrum longiradiatum*, etc.), but there was no evident increase in the number of the smaller species. The most interesting species of the Chlorophyceæ were *Lagerheimia splendens*, which was distinctly rare, *Kirchneriella lunaris*, and *Eudorina elegans*.

TABLE OF PHYTOPLANKTON.

The relative frequency of a species is indicated by the letters "ccc" = very abundant, "cc" = common, "c" = fairly common, "r" = infrequent, "rr" = rare, and "rrr" = very rare.

SPECIES.	1905.											1906.	
	Feb. 4th.	Mar. 4th.	Apr. 1st.	May 6th.	June 3rd.	July 1st.	Aug. 5th.	Sept. 2nd.	Oct. 7th.	Nov. 4th.	Dec. 2nd.	Jan. 6th.	Feb. 10th.
Chlorophyceæ.													
Oedogonium sp. (sterile)	...	...	...	...	...	...	...	...	...	r			
Mougeotia sp. (probably *M. victoriensis*)	c	r	...	...	rr	r	rrr	...	rr	rrr	r		
Spirogyra sp. (probably *S. gracilis*)	...	...	...	...	...	rrr	...	...	...	r			
Zygnema sp. (probably *Z. spontaneum*)	...	...	...	...	...	...	...	...	rr	rr	rr	rr	rrr
Gonatozygon monotænium, De Bary	...	...	...	...	...	...	...	...	...	rr	rr	r	
„ *Kinahani*, (Arch.) Rabenh.	...	rrr	...	...	rrr	r							
Closterium Kützingii, Bréb.	rr	rr	...	...	...	...	...	...	rr	...	...	...	rr
Pleurotænium mamillatum, G. S. West	rrr	r	rrr										
Micrasterias Hardyi, G. S. West	cc	cc	ccc	c	r	c	rr	r	rr	cc	ccc	c	rr
Cosmarium obsoletum, (Hantzsch) Reinsch	...	...	rr	rrr	...	...	...	...	...	...	...	rrr	
„ *Lundellii*, Delp.	...	...	rrr										
„ *granatum*, Bréb.	...	...	rr										
„ *moniliforme*, (Turp.) Ralfs, var. *limneticum*, W. & G. S. West	r	c	r	r	rr	rr	rrr	...	...	...	...	...	rr
„ *contractum*, Kirchn.	rr	c	c	c	...	...	...	...	...	...	rrr	rr	r
„ „ var. *ellipsoideum*, (Elfv.) W. & G. S. West	r	cc	r	rr	...	r	rr	rrr	rr	r	c	r	r
„ *bioculatum*, Bréb.	r	c	...	...	rr	...	...	...	...	...	rrr	rr	r
„ *perfissum*, sp. n.	...	rr	rr	rrr									
„ *achondroides*, sp. n.	rr	r	r	r	...	rr	rrr	...	...	r	rr		
„ *pseudoprotuberans*, Kirchn.	...	...	...	...	...	...	...	...	...	...	...	cc	
„ *bireme*, Nordst.	...	...	...	...	...	...	...	...	...	...	...	r	
„ *capitulum*, Roy & Biss., var. *australe*, G. S. West	c	ccc	r	r	...	...	...	...	...	rrr	rr	r	
„ *tortum*, Nordst. & Lagerh., forma *trigona*	cc	ccc	cc	...	...	...	...	...	...	...	rr	r	rr

Cosmarium ***impressulum***, Elfv.	...	rrr	rrr	...	...	...	...	...	...	...	...	o	
,, *turgidum*, Bréb., var. *ovatum*, Nordst.	...	...	rr										
,, *Regnesi*, Reinsch	...	...	rrr	...	...	...	...	...	...	...	...	r	
,, *Blyttii*, Wille	...	...	...	...	...	...	...	...	...	...	...	r	
,, *subtriordinatum*, W. & G. S. West, forma	rrr	rr	...	...	...	...	...	...	...	...	...	...	rrr
,, *quadrum*, Lund.	...	...	rrr										
,, *Hardyi*, G. S. West	rr	c	ccc	r	...	rr	rrr	rrr	...	rr	rr	rr	cc
Xanthidium hastiferum, W. B. Turn., forma	...	rr	r										
Arthrodesmus Incus, (Bréb.) Hass., forma *a*	...	...	...	rrr	...	...	...	...	...	...	..	rr	rr
,, ,, forma *b*	..	...	...	...	...	...	...	...	...	...	...	rr	rr
Staurastrum ***cuspidatum***, Bréb.	r	cc	c	r	...	rr	...	...	...	rr	rrr	r	rr
,, ***dejectum***, Bréb.	rr	r	r	rrr	...	...	...	...	...	...	...	...	rrr
,, *mucronatum*, Ralfs, var. *delicatulum*, G. S. West	cc	cc	r	...	...	...	...	...	...	...	...	...	r
,, *corniculatum*, Lund.	cc	cc	cc	rr	...	rrr	...	...	...	rrr	...	..	rr
,, ,, var. *spinigerum*, West	cc	cc	cc	...	...	...	...	...	...	...	...	...	r
,, *grande*, Bulnh.	...	rr	...	...	...	...	...	...	...	rr			
,, *muticum*, Bréb.	c	c	c	...	...	rr	rrr						
,, ,, var. *victoriense*, G. S. West	rr	c	c	c	rr	rrr	...	...	...	...	...	...	rrr
,, *lanceolatum*, Arch.	...	...	...	...	...	...	...	...	...	...	...	...	rrr
,, *lævispinum*, Biss., var. *subbrachiatum*, G. S. West	...	r	r										
,, *victoriense*, sp. n.	rrr	rr	rrr	rrr	rrr	rr	rrr	...	rrr	r	r	rrr	rrr
,, *leptacanthum*, Nordst.	c	c	c	r	rr	rrr	...	...	...	...	...	rr	r
,, *furcatum*, (Ehrenb.) Bréb.	...	...	rrr										
,, *senarium*, (Ehrenb.) Ralfs	...	rr	rr	rrr									
,, *patens*, W. B. Turn., var. *planctonicum*, G. S. West	rrr	r	rr	r									
,, *Avicula*, Bréb., var. *subarcuatum*, (Wolle) West	...	...	...	rrr									
,, *hexacerum*, (Ehrenb.) Wittr., var. *aversum*, W. & G. S. West	...	...	...	...	...	...	...	...	...	...	...	rr	
,, *tetracerum*, Ralfs	...	c	r	r	...	...	...	...	...	...	...	r	rr
,, *excavatum*, W. & G. S. West, forma	rr	rr	rrr	rrr	...	...	...	...	...	...	...	c	c
,, *assurgens*, Nordst., var. *victoriense*, var. n.	...	rr	rr	r	...	rrr	...	...	...	...	...	...	rr
,, *indentatum*, W. & G. S. West, forma	...	...	r	...	...	...	...	...	...	...	...	...	r
,, *paradoxum*, Meyen, var. *longipes*, Nordst.	rrr	rr	r	...	...	...	...	...	...	...	...	...	rrr
,, *longiradiatum*, W. & G. S. West	r	c	c	r	...	...	...	...	...	rr	r	r	c
,, *sagittarium*, Nordst.	...	rrr											
,, *sexangulare*, (Buln.) Rabenh.	rrr	r	rr	...	...	...	...	...	...	...	...	...	rrr
,, ,, var. *productum*, Nordst.	rrr												
Spondylosium papillosum, W. & G. S. West	...	rr	rr										
Sphærozosma excavatum, Ralfs	...	rr	...	rr									
,, *Aubertianum*, West, var. *Archerii* (Gutw.), W. & G. S. West.	...	...	...	...	...	...	...	...	...	...	rrr		

TABLE OF PHYTOPLANKTON (*continued*).

SPECIES.	1905.											1906.	
	Feb. 4th.	Mar. 4th.	Apr. 1st.	May 6th.	June 3rd.	July 1st.	Aug. 5th.	Sept. 2nd.	Oct. 7th.	Nov. 4th.	Dec. 2nd.	Jan. 6th.	Feb. 10th.
Chlorophyceæ (*cont.*).													
Onychonema filiforme, (Ehrenb.) Roy & Biss.	...	...	...	rrr									
Hyalotheca dissiliens, (W. Sm.) Bréb.	...	...	...	...	...	rr							
„ *mucosa*, (Dillw.) Ehrenb.	...	...	rrr	...	...	rrr	rrr	...	...	...	rrr		
Desmidium Swartzii, Ag.	...	rrr	rr	rr	rr	rrr	rr	...	...	...	...	...	rrr
„ *Baileyi*, (Ralfs) Nordst., var. *undulatum*, (Mask.) Nordst.	...	...	...	rrr									
Volvox aureus, Ehrenb.	...	...	...	...	...	...	...	...	...	c	c		
Eudorina elegans, Ehrenb.	...	rrr	rrr	rr	...	...	rrr	...	...	cc	c	...	rr
Pandorina Morum, (O. F. Müll. ?) Bory	...	...	...	...	...	...	...	...	...	...	rrr	rr	
Pediastrum duplex, Meyen, var. *clathratum*, A. Br.	...	c											
„ „ „ *reticulatum*, Lagerh.	rr	r	...	...	...	...	...	...	...	...	rr	ccc	c
Cœlastrum microporum, Näg.	...	...	...	...	...	...	...	...	...	rr	...	...	rrr
Crucigenia rectangularis, (Näg.) F. Gay	...	...	...	...	...	...	...	...	...	...	...	rrr	
Scenedesmus bijugatus, (Turp.) Kütz.	rr	r	...	...	...	...	...	...	...	...	...	rr	rrr
Ankistrodesmus falcatus, (Corda) Ralfs	rrr	r	r	...	...	...	...	...	...	...	...	r	rr
„ „ var. *biplex*, (Reinsch) G. S. West	...	...	rr										
„ „ var. *spiralis*, (W. B. Turner) G. S. West	...	rrr	rrr										
Closteriopsis longissima, Lemm.	...	c	rr										
Kirchneriella lunaris, (Kirchn.) Möb.	rrr	...	rr	...	...	...	...	...	...	...	...	rr	rr
Oocystis lacustris, Chodat	...	...	...	...	...	...	...	...	...	...	...	rr	rr
„ *parva*, W. & G. S. West	...	...	...	...	...	...	...	...	...	...	...	rr	
Nephrocytium lunatum, West	...	...	...	...	...	...	...	...	...	...	rrr	rrr	
Lagerheimia splendens, sp. n.	...	...	...	...	...	...	...	...	...	...	...	...	rr
Dictyosphærium pulchellum, Wood	r	cc	c	r									
Botryococcus Braunii, Kütz.	...	...	...	r	c	c	r	...	rrr	r	r	rr	rr
Glœocystis gigas, (Kütz.) Lagerh.	r	c	c	c	...	...	...	...	...	...	...	rr	r
Sphærocystis Schroeteri, Chodat	rr	r	r	c	cc	ccc	r	rr					
Tetraspora lacustris, Lemm.	...	...	...	...	...	...	...	r	cc	ccc	cc		

Bacillarieæ.													
Melosira granulata, Ralfs	cc	ccc	cc	r	rr	rr	rrr	rrr	r	cc	ccc	ccc	ccc
,, ,, var. *spinosa*, Schröd.	rrr	cc	ccc	r									
Cyclotella stelligera, Cleve & Grun.	...	...	...	...	...	rr							
Rhizosolenia morsa, W. & G. S. West	...	...	...	...	...	...	...	...	...	...	...	c	
Tabellaria flocculosa, (Roth) Kütz.	rr	rrr	rrr	rrr	rrr	rrr	...	rrr	rrr	rr	rrr	rr	rr
Synedra Ulna, (Nitzsch) Ehrenb.	...	...	...	...	...	rr	rr	r	rr				
,, ,, var. *splendens*, (Kütz.) Van Heurck	...	...	...	...	...	...	...	...	...	...	...	...	rrr
Cocconeis Placentula, Ehrenb.	...	...	...	r	...	rr							
Navicula viridis, Kütz.	...	...	...	...	...	...	...	...	rr	r			
,, *bicapitata*, Lagerst. (a form)	...	...	...	rrr	...	...	...	...	rr	c			
Vanheurckia viridula, Bréb.	...	...	rr	rrr	...	rrr							
Gyrosigma elongatum, W. Sm., var. ?	..	...	...	...	...	...	...	...	...	rrr			
Gomphonema gracile, Ehrenb.	r												
,, *constrictum*, Ehrenb.	...	...	...	...	...	rrr							
Rhopalodia gibba, (Kütz.) O. Müll.	...	...	...	rr									
Nitzschia curvula, (Ehrenb.) W. Sm.	...	...	...	...	...	rrr							
,, *Palea*, (Kütz.) W. Sm.	...	...	...	...	...	...	...	...	...	r			
Surirella robusta, Ehrenb., var. *splendida*, (Ehrenb.) Van Heurck	...	r	r	...	...	r	rr	rr	...	r			
,, *ovalis*, Bréb.	...	...	...	...	...	...	...	...	...	rrr			
Myxophyceæ.													
Anabæna sp. (sterile)	...	...	...	rrr	...	r							
Plectonema sp. ? (fragmentary)	...	...	...	...	...	...	...	...	...	rr			
Oscillatoria Agardhii, Gom.	...	...	...	...	...	c	r	...	...	...	rr		
Chroococcus limneticus, Lemm., var. *subsalsus*, Lemm.	rr	r	c										
Peridinieæ.													
Peridinium Volzii, Lemm., var. *australe*, var. n.	...	...	rr	rr	...	...	...	...	...	c	r	r	c
Flagellata.													
Dinobryon cylindricum, Imhof	c	ccc	rr	...	...	rr	...	...	...	cc	c	c	cc
,, ,, var. *divergens*, (Imhof) Lemm.	r	ccc	r	...	...	...	...	...	...	c	ccc	ccc	
,, *elongatum*, Imhof, var. *undulatum*, Lemm.	...	r											

Dominant Forms and their Periodicity.

Flagellata.—Two species and two varieties of the genus *Dinobryon* formed a characteristic part of the plankton. They attained their maximum very rapidly, occurring in abundance from February (or even December) to March, with a water-temperature of 18°–20° C. All the forms disappeared with equal rapidity, and were entirely absent from May to October. The occurrence of *Dinobryon* only in the warmer part of the year is a fact which calls for special mention. In the British lakes this genus reaches its maximum in spring, generally in May, at a time when the temperature of the surface-water is little more than half the average summer temperature. This is in agreement with the observations of Tanner-Fullemann on the occurrence of *Dinobryon* in certain of the Swiss alpine lakes *, and Ostenfeld

Fig. 3.

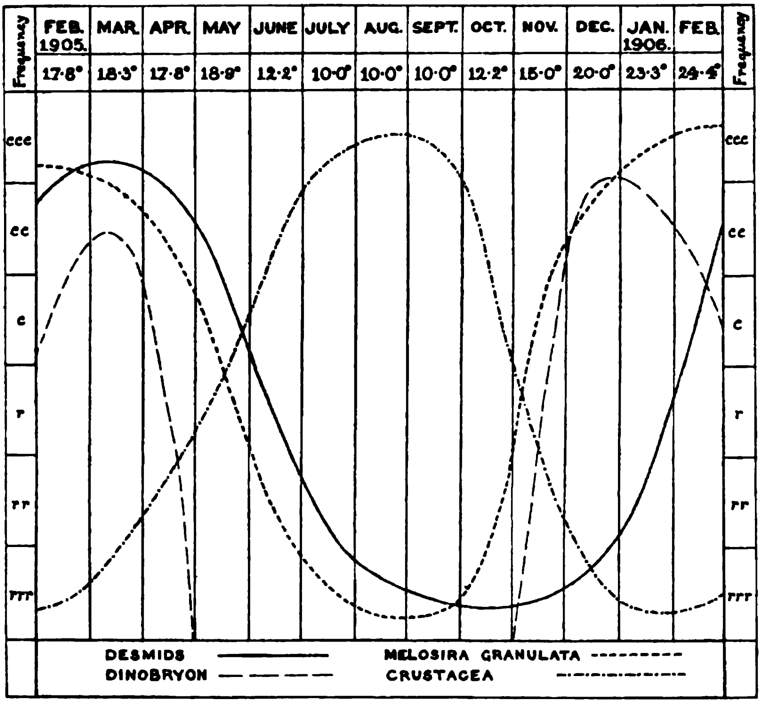

Chart showing the periodicity of the dominant constituents of the Yan Yean plankton. The relative frequency is indicated by the same lettering as in the Table of Phytoplankton.

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* M. Tanner-Fullemann, in Bull. de l'Herb. Boissier, 2me sér., vii. (1907) p. 226. [Max. development in May with a water-temperature of 11° C.]

and Wesenberg-Lund [*] state that *Dinobryon* is a prominent feature of lakes of higher altitudes in which the temperature of the water is never very high. In the Danish lakes, Wesenberg-Lund [†] also finds the maximum to occur in May. In the "Altwässer" of the Danube, Brunnthaler [‡] records the maximum of *D. Sertularia* var. *thrysoideum* as occurring in January, that of *D. cylindricum* var. *divergens* in May, and that of *D. sociale* in June. In the Yan Yean plankton the maximum of *D. cylindricum* (and also its var. *divergens*) occurs from 18°–20° C., whereas in the European plankton the maximum is attained at a temperature below 15° C. In the lakes of tropical Africa, with a mean surface temperature of over 20° C., *Dinobryon* is entirely absent [§].

Peridinieæ.—Only one species of this group occurred in the plankton. This form, *Peridinium Volzii* var. *australe*, which is of great interest from a classificatory point of view, had two maxima, the first in November, with a temperature of 15° C., and the second in February, with a temperature of 24·4° C.

Chlorophyceæ.—Fragments of *Mougeotia* were not uncommon, but no coiled filaments were observed such as occur in the British freshwater plankton. *The dominant Chlorophyceæ are Desmids.* From February to May the plankton has all the characters of a Desmid-plankton. They attain their maximum from February to April, at a time when the temperature of the water is at its highest and when the Crustacea are least in evidence. The most conspicuous of these Desmids is *Micrasterias Hardyi*, a handsome species which up to the present is only known to occur in this one lake [‖]. It is never absent from the plankton, and appears to have two maxima: the first in April (temp. 17·8° C.), and the second in December (temp. 20° C.). *Cosmarium Hardyi*, with its maximum in April, and *C. contractum* are both conspicuous constituents of the plankton, especially the former. *Staurastrum leptacanthum* is common from February to April, and the extraordinary *S. victoriense*, although always a scarce constituent, was only absent from the plankton in September. In all, 58 species of Desmids occurred in the plankton, many of them abundantly. *Volvox aureus* and *Eudorina elegans* were present in November and December, the latter also occurring very sparingly at other times of the year. The former may be only a casual, but the latter is a true plankton-alga both here and in Europe. *Botryococcus Braunii* occurred only in June and July. *Sphærocystis Schroeteri* occurred from February to September, attaining its maximum from June to July. In the systematic part of this paper I have given reasons for considering this Alga and *Tetraspora lacustris* as different stages of one and the same organism (consult page 75). The *Tetraspora*-stage commenced in October and reached its maximum in November. Wesenberg-Lund *, from the experience of his Danish plankton investigations, states that he is inclined to believe that the two are not identical.

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[*] C. H. Ostenfeld & C. Wesenberg-Lund, in Proc. Roy. Soc. Edin. xxv. part xii. (1906) p. 1098.

[†] C. Wesenberg-Lund, "Studier over de Danske Söers Plankton," Dansk. Ferskv.-Biol. op. 5, Kjöbenhavn, 1904, p. 115 ("Summary," p. 26).

[‡] J. Brunnthaler, in Verh. der k.k.zool.-bot. Ges. Wien (1907), p. 185.

[§] G. S. West, in Journ. Linn. Soc., Bot. xxxviii. (1907) p. 84.

[‖] This species may occur in other parts of Victoria, or of Australasia, but Mr. Hardy's careful collections have failed to reveal its presence in any other part of the Yan Yean drainage area. Should *Micrasterias Hardyi* be restricted to this one lake, it will afford a parallel to the occurrence of *M. Murrayi*, W. & G. S. West, in the plankton of Loch Ruar, Sutherland. (*Vide* W. & G. S. West, in Journ. Linn. Soc., Bot. xxxv. (1903) p. 538.)

Fig. 4.

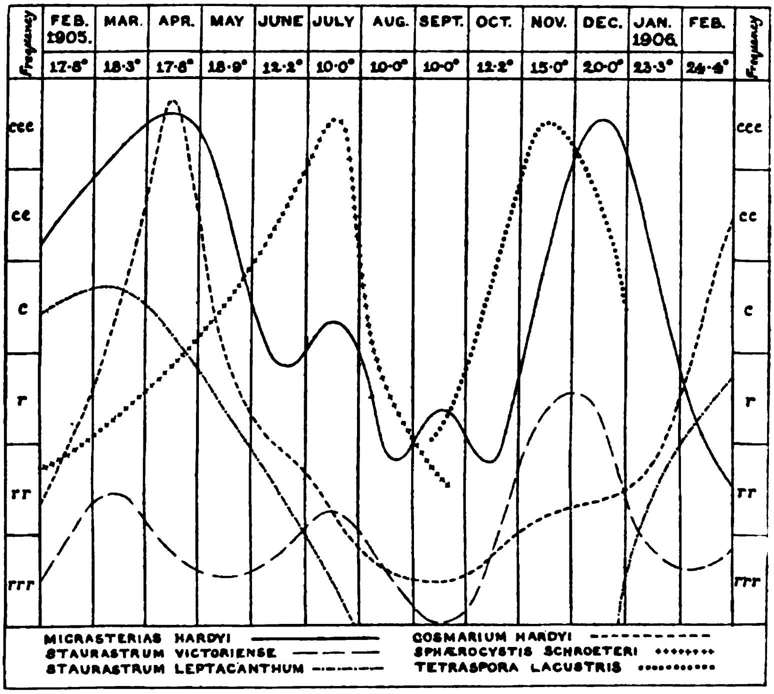

Chart showing the periodicity of six of the characteristic Chlorophyceæ of the Yan Yean plankton.

Bacillarieæ.—Diatoms are not a feature of the Yan Yean plankton, although *Melosira granulata* occurs abundantly and is never absent from the collections. It is most conspicuous from November to April, and reaches its maximum in February, when the temperature of the water averages 21° C. Auxospore-formation took place in January ; that is to say, at approximately the period of highest temperature *. No coiled filaments were observed such as occur in the plankton of certain European lakes. *Rhizosolenia morsa* occurred abundantly in January (temp. of water 23·3° C.), but was not observed in any other month. As in the British plankton †, this Diatom is apparently a summer (or warm-water) species with a very brief vegetative period. Of the Naviculaceæ, *Navicula bicapitata* was common in November, and *Vanheurckia viridula* was scarce from April to July. Both these species are shore forms and occurred abundantly in the benthos ; but it is worthy of note that the plankton-specimens of the latter species were of much greater size than those observed from any other situation. Species of *Gyrosigma* are not infrequently met with in the freshwater plankton, but the species which occurred in the November plankton of the Yan Yean is of more than ordinary interest. It occurred very sparingly, and it is much more nearly allied to certain of the marine species of the genus than to any of the known freshwater species. For the present I have regarded it as possibly a variety of *Gyrosigma elongatum* (consult p. 79). *Tabellaria flocculosa*, although never frequent, was present in all the collections except those made in August.

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* C. Wesenberg-Lund, *l. c.* [*cf.* p. 19] (1904) p. 21 of Summary.

Myxophyceæ.—The remarkable scarcity of Blue-green Algæ has already been commented upon. *Oscillatoria Agardhii* was common in July, and *Chroococcus limneticus* var. *subsalsus* occurred abundantly in April. There is no phase of the plankton in which Blue-green Algæ dominate such as occurs in so many European ‡ and N. American lakes §.

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* In the report upon the plankton of Thingvallavatn, Iceland, C. H. Ostenfeld & C. Wesenberg-Lund record the auxospore-formation of *Melosira islandica* as commencing rather suddenly between the middle of December and the middle of January (temp. 1°–2° C.); *vide* Proc. Roy. Soc. Edin. xxv. part xii. (1906) p. 1117. This is in striking contrast to the auxospore-formation of *M. granulata* in the Yan Yean at a temp. of 23·3° C.

† W. West & G. S. West, in Trans. Roy. Soc. Edin. xli. part iii. (1905) p. 509; Trans. Roy. Irish Acad. xxxiii. sect. B, part ii. (1906) p. 109.

‡ Consult B. Schröder, "Das Pflanzenplankton preussischer Seen," Westpreuss. Bot.-Zool. Verein, Danzig (1900), p. 73 ; E. Lemmermann, "Das Phytoplankton einiger Plöner Seen," Forschungsb. Biol. Stat. Plön, x. (1903) p. 126 ; K. v. Keissler, in Oesterr. botan. Zeitschr. (1906) no. 5-6, p. 4 ; H. Huitfeldt-Kaas, 'Planktonundersogelser Norske Vande,' Christiania (1906), p. 152 ; and many others.

§ C. Dwight Marsh, in Bull. Wisconsin Geol. and Nat. Hist. Survey, Sci. ser. 3, xii. p. 15; and others.

II. THE LITTORAL ALGA-FLORA (OR MICROPHYTIC BENTHOS).

GENERAL NOTICE.

Although careful investigations have been carried out on the phytoplankton of many lakes, more especially in Europe and North America, very few detailed observations have been made on the benthos of these lakes with a view to discovering the relationships between the littoral species and those of limnetic habit. Such observations, to be of any real worth, necessarily demand a very extensive preliminary training in systematic work, and some of the recent publications exhibit only too clearly an insufficient knowledge of the plants dealt with. In many cases this has resulted in conclusions having been put forward which are of very doubtful value.

Among the weeds at the margins of the Yan Yean Reservoir, and especially in the vicinity of Honeysuckle Flat, there is a prolific Alga-flora which constitutes the microphytic part of the benthos and affords an interesting comparison with the phytoplankton. The collections were made periodically on the same day as the plankton-collections, and the variations of temperature, both of the water and the atmosphere, can be regarded as approximately the same as those tabulated in respect of the phytoplankton.

The large weedy tract of the eastern bay of the lake, to which Mr. Hardy has given the name of Honeysuckle Flat, appears to be the principal recruiting ground for many species found in the plankton, and the periodic collections from among the weeds were all made in this swampy area. Numerous wild fowl, such as ducks, coot, teal, black swans, herons, cormorants, etc., haunt this weedy flat, and deposit much excreta, some of which forms in the shallower parts a greasy scum on the surface. As the diet of these water-fowl is largely one of perch, blackfish, trout, etc., the mud of the reservoir must be considerably enriched by additional phosphates. The weed-collections were always made outside the feeding-ground of the water-fowl, generally from unnibbled weeds in from two to five feet of water. The coating of Algæ was most evident on *Triglochin procera*, *Potamogeton obtusus*, *Heleocharis sphacelata*, and *Myriophyllum variifolium*; and some of the larger species of the genus *Staurastrum* (especially *S. leptacanthum* and *S. victoriense*) were more than ordinarily prolific on the leaves of *Vallisneria spiralis*.

As is commonly the case, and would naturally be expected, the algal species observed among the littoral macrophytes were considerably more numerous than those found in the plankton.

MONTHLY STATEMENT OF THE MICROPHYTIC BENTHOS FROM FEB. 1905 TO JAN. 1906.

Feb. 4th, 1905.—Desmids dominant, with few Myxophyceæ and Diatoms. The Protococcoideæ were only represented by a few specimens of *Pediastrum Tetras.*

Mar. 4th, 1905.—Desmids dominant, mostly small species. Zygospores of *Cosmarium contractum* not uncommon. A species of *Chytridium* was abundant, parasitic on certain species of *Cosmarium.* A decided increase in the number of Protococcoideæ.

April 1st, 1905.—Desmids dominant, having reached their maximum abundance. The most conspicuous species were *Cosmarium obsoletum* and *Staurastrum senarium.* Diatoms numerous. A species of *Anabæna* occurred and showed indications of spore-formation. Sterile species of *Mougeotia* not uncommon.

May 6th, 1905.—Desmids still dominant, but great diminution in the bulk of the material. Much decomposition had taken place, and the material consisted largely of decaying organic matter. The *Anabæna* sp. was still evident, but the filaments were in a very fragmentary condition.

June 3rd, 1905.—Desmids very abundant, especially *Cosmarium contractum* and its var. *ellipsoideum, Staurastrum muticum, S. corniculatum, S. leptacanthum,* and *S. victoriense.* Diatoms few as regards individuals, but 20 species represented.

July 1st, 1905.—Desmids dominant and most of them in a state of active division. The most conspicuous were *Staurastrum cuspidatum, S. muticum, S. victoriense, S. assurgens,* and *Cosmarium contractum* var. *ellipsoideum.* The Myxophyceæ were represented by quantities of *Oscillatoria Agardhii* and somewhat fragmentary filaments of the same species of *Anabæna* as occurred in April and May. Number of Diatoms increased, more especially due to the multitude of individuals of some of the smaller species.

Aug. 5th, 1905.—Desmids practically disappeared; only living ones were *Closterium Venus, Staurastrum cuspidatum,* and *S. sagittarium,* all of which were very scarce. Various dead and half-decayed remains of numerous species were conspicuous. The other Chlorophyceæ have also disappeared. One solitary *Volvox* colony was seen. Diatoms more numerous and more conspicuous; especially noticeable were the large individuals of *Eunotia major* var. *bidens.* A few Crustacea were present, and also a Tardigrade (a small sp. of *Macrobiotus*).

Sept. 2nd, 1905.—No Chlorophyceæ observed. Fewer Diatoms than in preceding month, both of species and individuals. Rather more of the small Crustacea than in August.

Oct. 7th, 1905.—A few Chlorophyceæ had made their appearance, mostly Desmidiaceæ. A few of the smaller Desmids were not uncommon, and *Cosmarium amœnum* var. *mediolæve* was conspicuous. Filaments (sterile) of a small species of *Mougeotia* were not infrequent. A few Diatoms were fairly general, and *Vanheurckia viridula* was abundant.

Nov. 4th, 1905.—The littoral Alga-flora very rich. Five species of *Oedogonium* and one of *Bulbochæte* with ripe oospores. *Zygnema spontaneum* and five species of *Mougeotia* in fruiting condition, of which *M. subcrassa* and *M. victoriensis* are interesting new species. *Spirogyra gracilis* in conjugation. Protococcoideæ represented by a multitude of small species. Also a vast number of very small species of Desmids, of which *Cosmarium capitulum* var. *australe*, *C. quadratulum*, and *Staurastrum bibrachiatum* var. *cymatium* were particularly conspicuous. Diatoms numerous, but species relatively few.

Dec. 2nd, 1905.—Three species of *Oedogonium* and one of *Bulbochæte* were in a fruiting condition. Large quantities of sterile filaments of *Zygnema spontaneum*, and a few with zygospores, were observed. Intermingled with the *Zygnema* were fruiting specimens of *Mougeotia subcrassa* and *Spirogyra gracilis.* Small species of Desmids were very numerous, and one specimen of *Micrasterias Hardyi* was observed. There were a number of Protococcoideæ, of which *Glœocystis gigas* was the most conspicuous, while species of *Scenedesmus* and *Cœlastrum sphœricum* were fairly general. The conspicuous Diatoms were *Tabellaria flocculosa*, *Vanheurckia viridula*, and *Synedra Acus.* *Dinobryon cylindricum* (with its var. *divergens*) was abundant, and *Trachelomonas hispida* was not uncommon. The dominant feature was the enormous abundance of the smaller species of Desmids.

Jan. 6th, 1906.—The amount of *Zygnema*, *Mougeotia*, and *Oedogonium* greatly diminished. The most interesting Conjugate was *Debarya Hardyi* in all stages up to the formation of ripe zygospores. The smaller species of Desmids were still abundant, although not quite so numerous as in the preceding month. *Gonatozygon monotænium* was conspicuously abundant. One specimen of *Micrasterias Hardyi* was again observed. Of the Protococcoideæ, *Ankistrodesmus* and *Scenedesmus* were the most frequent. There was a considerable increase in the number of Diatoms, more especially in individuals. The species of Diatoms were few, *Synedra Ulna* and *Tabellaria flocculosa* being the most conspicuous. The dominant features were the two Diatoms just mentioned and the numerous small species of Desmids. Many species of *Cosmarium* (especially *C. obsoletum*) and the zygospores of *Spirogyra gracilis* were attacked by *Myzocytium proliferum*, Schenk, one of the Chytridiaceæ.

TABLE OF LITTORAL ALGA-FLORA.

As in the tabulated list of phytoplankton, the relative frequency of a species is indicated by the letters "ccc"= very abundant, "cc"= common, "c"= fairly common, "r"= infrequent, "rr"= rare, and "rrr"= very rare.

SPECIES.	1905.											1906.
	Feb. 4th.	Mar. 4th.	Apr. 1st.	May 6th.	June 3rd.	July 1st.	Aug. 5th.	Sept. 2nd.	Oct. 7th.	Nov. 4th.	Dec. 2nd.	Jan. 6th.
Chlorophyceæ.												
Oedogonium cryptoporum, Wittr.	...	...	...	...	...	...	...	...	...	c	r	
" " var. *vulgare*, Wittr.	...	...	...	...	...	...	...	...	...	r	r	
" *oblongum*, Wittr.	...	...	...	...	...	...	...	...	...	c	r	
" *platygynum*, Wittr.	...	...	...	...	...	...	...	...	...	rr		
" *flavescens*, (Hass.) Wittr.	...	...	...	...	...	...	...	...	...	rr	rr	
" *suecicum*, Wittr., forma *australis*	...	...	...	...	...	...	...	...	...	rrr		
" *undulatum*, (Bréb.) A. Br.	...	...	...	...	...	...	...	...	...	rr		
" *monile*, Berk. & Harv., forma *victoriense*	...	...	...	...	...	...	...	...	...	...	r	
Bulbochæte crassiuscula, Nordst.	...	...	...	...	...	...	...	...	...	...	r	rr
" *subintermedia*, Elfv.	...	...	...	...	...	...	...	...	...	rr		
Coleochæte irregularis, Pringsh.	rr	rr										
Ulothrix idiospora, sp. n.	...	...	...	...	...	...	...	...	...	r		
Mougeotia parvula, Hass.. var. *angusta*, (Hass.) Kirchn.	...	...	...	...	...	...	...	...	...	rrr		
" *victoriensis*, sp. n.	...	...	...	...	...	...	...	...	...	cc		
" *recurva*, Hass.	...	...	...	...	...	...	...	...	...	rr		
" *subcrassa*, sp. n.	...	...	...	...	...	...	...	...	...	r	rrr	
" *viridis*, (Kütz.) Wittr.	...	...	...	...	...	...	...	...	r			
Debarya Hardyi, sp. n.	...	...	...	...	...	...	...	...	...	...	...	r
Zygnema spontaneum, Nordst.	...	...	...	...	...	...	...	...	...	cc	c	r
Spirogyra gracilis, (Hass.) Kütz.	...	...	...	...	...	...	...	...	...	r	r	rr
Gonatozygon monotænium, De Bary	...	r	...	rr	rr	...	...	...	...	...	r	ccc
" *Brébissonii*, De Bary	...	...	...	...	...	...	...	...	...	rrr	rrr	
" *Kinahani*, (Arch.) Rabenh.	...	...	rrr	...	rrr							
Cylindrocystis diplospora, Lund.	rrr	r	r	...	...	...	...	...	...	...	rrr	

TABLE OF LITTORAL ALGA-FLORA (*continued*).

SPECIES.	1905.											1906.
	Feb. 4th.	Mar. 4th.	Apr. 1st.	May 6th.	June 3rd.	July 1st.	Aug. 5th.	Sept. 2nd.	Oct. 7th.	Nov. 4th.	Dec. 2nd.	Jan. 6th.
Chlorophyceæ (*cont.*).												
Closterium macilentum, Bréb.	...	...	...	...	rr							
„ *Dianæ*, Ehrenb.	...	rrr	...	...	rrr							
„ *parvulum*, Näg.	...	...	...	...	rr							
„ „ var. *angustum*, W. & G. S. West	...	rrr	rrr	r	...	...	...	...	...	...	rr	rr
„ *Venus*, Kütz.	rrr	rrr	rrr	rr	r	r	rr	...	...	...	rrr	
„ *calosporum*, Wittr.	rrr	rrr										
„ *incurvum*, Bréb.	...	...	...	...	...	...	...	...	...	rr	rr	rrr
„ *Lunula*, (O. F. Müll.) Nitzsch	...	...	rrr	...	...	rrr						
„ *aciculare*, T. West, var. *subpronum*, W. & G. S. West.	...	...	...	...	...	...	...	...	...	...	rrr	rrr
Pleurotænium Ehrenbergii, (Bréb.) De Bary	...	...	...	...	...	...	...	...	...	rrr		
„ *mamillatum*, G. S. West	...	...	...	...	...	rrr						
„ *coronatum*, (Bréb.) Rabenh.	...	...	...	...	...	...	...	...	...	...	...	rrr
„ *ovatum*, Nordst., var. *tumidum*, Mask.	...	...	...	...	...	...	...	...	...	rrr	rrr	
„ *nodosum*, (Bail.) Lund.	...	...	...	...	...	...	...	...	...	rrr	rrr	
Triploceras gracile, Bail., var. *aculeatum*, Nordst., forma	...	rrr										
„ „ var. *robustum*, var. n.	...	...	...	...	...	...	...	...	...	...	...	rr
„ „ var. *denticulatum*, (Playfair) nob.	...	rrr										
Euastrum denticulatum, (Kirchn.) F. Gay, forma	...	...	r	rr	rr	rr	...	...	...	...	rr	rr
„ *crispulum*, (Nordst.) W. & G. S. West	...	rr	rrr									
„ *Turnerii*, West, forma *minor*	...	...	...	rrr	...	...	...	...	rr	cc	cc	c
Micrasterias Hardyi, G. S. West	...	...	...	...	...	...	...	...	...	...	rrr	rrr
Cosmarium obsoletum, (Hantzsch) Reinsch	rr	r	cc	c	c	r	...	...	...	...	rrr	rrr
„ *dorsitruncatum*, (Nordst.) nob.	r	r	r	...	...	...	...	...	rrr			
„ *granatum*, Bréb.	...	rr	r	...	...	rrr	...	...	...	rr	r	c
„ *moniliforme*, (Turp.) Ralfs	...	...	rr									
„ „ var. *limneticum*, W. & G. S. West	...	...	r	rr	r	c	...	...	...	rrr	r	
„ *affine*, Racib., var. *excavatum*, var. n.	...	rrr										
„ *tinctum*, Ralfs	...	...	...	...	...	...	...	...	...	...	rrr	
„ *contractum*, Kirchn.	rr	r	r	rr	c	rr	...	...	...	...	rr	rr
„ „ var. *ellipsoideum*, (Elfv.) W. & G. S. West	...	cc	cc	ccc	ccc	r	...	...	...	...	r	

Cosmarium tjibenongense, Gutw., forma	...	...	...	...	rrr							
„ *bioculatum*, Bréb.	rr	c	r	r	r	c	...	...	rr	r	c	
„ *perfissum*, sp. n.	...	r	r	rr	rr	rr	...	...	...	...	rrr	
„ *achondroides*, sp. n.	...	rr	r	r	cc	r	...	...	...	r	rr	
„ *abbreviatum*, Racib.	...	...	rr	rr	r	r	...	...	rr	c	r	rr
„ *pygmæum*, Arch.	rr	c	r	...	...	...	...	...	...	cc	c	r
„ *pseudoprotuberans*, Kirchn., var. *angustius*, Nordst.	...	...	...	...	...	...	...	...	...	...	r	rr
„ *sexangulare*, Lund., forma *minima*, Nordst.	...	...	...	...	...	...	...	...	...	...	rr	rrr
„ *bireme*, Nordst.	...	...	...	...	...	...	...	...	...	rr	r	
„ *Phaseolus*, Bréb., forma	...	c	r	...	rr	r	...	...	...	...	rr	rr
„ *capitulum*, Roy & Biss., var. *australe*, G. S. West	...	cc	c	...	rrr	rrr	...	...	...	ccc	cc	c
„ *Murrayi*, Playfair	...	...	...	...	...	...	...	...	...	rrr		
„ *Regnellii*, Wille	...	rrr	...	rrr	...	...	...	...	...	rr	rrr	
„ *angulosum*, Bréb.	...	r	...	...	r	...	...	...	...	cc	c	r
„ „ var. *concinnum*, (Rabenh.) W. & G. S. West	...	rr	r	...	...	...	...	...	...	...	c	rr
„ *quadratulum*, (F. Gay) De Toni	...	...	...	...	...	...	...	...	...	ccc	cc	c
„ *difficile*, Lütkem., var. *sublæve*, Lütkem.	rr	r	r	r	rr	rrr	...	...	...	...	...	rrr
„ *impressulum*, Elfv.	...	...	rrr	...	...	...	...	...	...	c	c	r
„ *venustum*, (Bréb.) Arch., var. *induratum*, Nordst.	...	...	...	...	...	...	...	...	...	...	...	rrr
„ *gonoides*, W. & G. S. West, var. *subturgidum*, W. & G. S. West.	...	...	...	...	...	r						
„ *Regnesi*, Reinsch	...	...	...	...	...	...	...	...	...	r	r	rrr
„ *abruptum*, Lund., var. *granulatum*, W. & G. S. West.	...	...	...	...	...	...	...	...	...	...	rr	rrr
„ *Blyttii*, Wille	...	...	...	...	...	...	...	...	...	r	rr	r
„ *subpunctulatum*, Nordst.	...	rrr	...	rrr	rrr	rrr	...	...	...	...	rr	
„ *subtriordinatum*, W. & G. S. West, forma	...	rr	rr	r	...	...	...	...	...	rr	r	rrr
„ *amœnum*, Bréb., var. *mediolæve*, Nordst.	c	r	rr	rr	r	rrr	...	...	r	rr	rrr	rr
„ *Hardyi*, G. S. West	...	...	rrr	rrr								
„ *binum*, Nordst.	...	rrr	rrr	r	rr	rrr						
Xanthidium hastiferum, W. B. Turn., forma	...	rr	...	rr	rrr							
Arthrodesmus Incus, (Bréb.) Hass., forma *a*	...	rr	rr	rr	rr	...	...	...	...	...	...	rrr
„ „ forma *b*	...	...	...	...	...	...	...	...	...	...	...	rrr
„ *triangularis*, Lagerh.	...	...	...	...	...	...	...	...	...	rr		
„ „ forma *minor*	...	...	r	rr	rrr	...	...	...	...	rr	rr	rrr
Staurastrum cuspidatum, Bréb. [inclus. var. *divergens*, Nordst.]	r	ccc	c	c	r	ccc	rrr	...	...	r	r	rr
„ *dejectum*, Bréb.	r	cc	c	r	rr	...	...	...	...	rr	rr	rrr
„ *Dickiei*, Ralfs	...	rr	rrr									
„ *mucronatum*, Ralfs, var. *delicatulum*, G. S. West	...	...	...	rrr	...	rr						
„ *corniculatum*, Lund.	...	r	c	r	cc	c						
„ „ var. *spinigerum*, West	...	c	c	...	rr	rr						
„ *grande*, Bulnh.	...	...	rr	...	rrr	rrr						

TABLE OF LITTORAL ALGA-FLORA (*continued*).

Species.	1905.											1906.
	Feb. 4th.	Mar. 4th.	April 1st.	May 6th.	June 3rd.	July 1st.	Aug. 5th.	Sept. 2nd.	Oct. 7th.	Nov. 4th.	Dec. 2nd.	Jan. 6th.
Chlorophyceæ (*cont.*).												
Staurastrum muticum, Bréb.	...	rr	cc	c	ccc	c						
,, *Bieneanum*, Rabenh.	...	...	...	...	...	rrr						
,, *lanceolatum*, Arch.	...	...	rrr	...	...	...	...	...	rrr	rrr	rrr	rr
,, *digitatum*, sp. n.	...	rrr	rr									
,, *victoriense*, sp. n.	...	...	rrr	r	c	cc						
,, *leptacanthum*, Nordst.	...	r	r	c	cc	r						
,, *furcatum*, Ehrenb.	...	r	c	r	c	c						
,, *senarium*, (Ehrenb.) Ralfs	rr	rr	c	r	rrr	rrr						
,, *unicorne*, W. B. Turn., var. *nodiferum*, (W. B. Turn.) W. & G. S. West.	...	rrr										
,, *punctulatum*, Bréb.	rrr	rr										
,, *dilatatum*, Ehrenb., var. *obtusilobum*, De Not.	...	...	r	...	...	...	...	...	...	...	rrr	rr
,, *alternans*, Bréb.	...	...	...	...	...	rr	...	...	...	...	rr	rrr
,, *hexacerum*, (Ehrenb.) Wittr.	rr	c	r	...	...	rrr	...	...	...	cc	c	c
,, ,, var. *aversum*, W. & G. S. West	...	...	...	...	...	...	...	...	...	...	c	c
,, *polymorphum*, Bréb.	...	...	...	...	...	...	...	...	...	...	...	rrr
,, *cyrtocerum*, Bréb.	rrr	r										
,, *neglectum*, sp. n.	...	rrr	r	rr	...	rrr						
,, *tetracerum*, Ralfs	...	c	...	rrr	rrr	c	...	...	...	c	rr	c
,, *bibrachiatum*, Reinsch, var. *cymatium*, W. & G. S. West	...	...	...	...	...	rrr	...	...	...	cc	r	rr
,, *excavatum*, W. & G. S. West, forma	...	c	r	...	rrr	rr	...	...	...	cc	c	rr
,, *Hardyi*, sp. n.	...	...	...	...	...	rr	...	...	...	c	cc	r
,, *assurgens*, Nordst., var. *victoriense*, var. n.	r	cc	cc	c	c	c	...	...	...	...	r	r
,, *indentatum*, W. & G. S. West, forma	...	rr	r	rr	rr	rr						
,, *leptocladum*, Nordst.	rrr	r	...	...	...	...	...	...	...	rrr		
,, *longiradiatum*, W. & G. S. West	...	...	rrr	rr	...	rr	...	...	...	rr	r	r
,, ,, var. *subnudum*, var. n.	...	...	...	...	...	...	...	...	...	...	c	rr
,, *sagittarium*, Nordst.	rrr	rr	rrr	...	...	...	rrr	...	...	rrr	rrr	rrr
,, *sexangulare*, (Bulnh.) Rabenh.	...	...	rrr	...	...	...	...	...	rrr	rrr	rrr	rr
Spondylosium secedens, (De Bary) Arch.	...	rrr										

Sphærozosma excavatum, Ralfs	...	...	...	...	rrr							
,, *Wallichii*, Jacobsen, forma *australis*	...	...	...	...	...	rrr						
,, *Aubertianum*, West	...	...	...	...	rrr	rrr	...	...	...	r	rr	r
Onychonema filiforme, (Ehrenb.) Roy & Biss.	rr	rr	rr	rrr	rr	rr	...	...	...	rrr	rr	c
Hyalotheca dissiliens, (W. Sm.) Bréb.	...	...	...	...	...	...	...	...	...	...	rrr	
,, *hians*, Nordst.	...	...	...	...	...	...	...	...	...	...	rrr	
,, *mucosa*, (Dillw.) Ehrenb.	...	...	...	rrr								
Desmidium Swartzii, Ag.	...	rr	rrr	...	...	rr						
,, *aptogonum*, Bréb.	...	...	...	...	...	...	...	...	...	...	...	r
,, *Baileyi*, (Ralfs) Nordst., var. *undulatum*, (Mask.) Nordst.	r	rrr	rrr	...	...	rrr	...	...	...	rr	r	c
Volvox aureus, Ehrenb.	...	...	...	...	...	...	rrr					
Eudorina elegans, Ehrenb.	...	...	...	...	...	...	...	...	...	...	rrr	
Pandorina Morum, (O. F. Müll.) Bory	...	...	...	...	...	...	...	...	...	rrr	rr	rrr
Gonium pectorale, O. F. Müll.	...	...	...	...	...	...	...	...	...	rr		
Pediastrum duplex, Meyen, var. *reticulatum*, Lagerh.	...	...	...	...	...	...	...	...	...	...	rr	r
,, *Boryanum*, (Turp.) Menegh.	...	...	...	...	...	rrr	...	...	...	...	rr	r
,, *Tetras*, (Ehrenb.) Ralfs	rrr	rr	...	...	...	...	...	...	...	rr	r	rrr
Cœlastrum sphæricum, Näg.	rrr	...	...	...	...	r	...	...	...	...	r	rrr
,, *microporum*, Näg.	...	...	...	...	...	...	...	...	...	rrr	r	
Crucigenia rectangularis, (A. Br.) Gay	...	...	...	...	rrr							
Scenedesmus bijugatus, (Turp.) Kütz.	...	rr	...	...	...	r	...	...	...	c	rr	c
,, *obliquus*, (Turp.) Kütz.	...	...	...	...	...	...	...	...	...	...	...	r
,, *acutiformis*, Schröder	...	...	...	...	...	...	...	...	...	...	rr	r
,, *denticulatus*, Lagerh., var. *linearis*, Hansg.	rr	r	rr	rr	rr	c	...	...	...	r	...	c
,, *quadricauda*, (Turp.) Bréb.	...	...	...	...	...	...	...	...	...	...	...	rr
Ankistrodesmus falcatus, (Corda) Ralfs	rr	r	rr	r	r	c	...	...	...	c	r	r
,, ,, var. *acicularis*, (A. Br.) G. S. West	...	rr	...	...	r	r	rrr	...	...	...	rr	c
,, ,, var. *spiralis*, (W. B. Turn.) G. S. West	...	...	...	rrr	...	rr	...	...	...	...	rrr	rr
Oocystis solitaria, Wittr.	...	rr	...	...	...	rr	...	...	...	cc	c	r
,, *submarina*, Lagerh., forma *major*	...	rr										
Nephrocytium Agardhianum, Näg.	...	...	...	...	...	...	...	...	...	...	...	rrr
,, *lunatum*, West	...	rr	rr	...	...	rrr	...	...	...	r	r	r
Tetraëdron minimum, (A. Br.) Hansg.	...	r	...	...	rr	r	rr	...	...	...	c	
,, *caudatum*, (Corda) Hansg.	...	...	...	...	...	...	...	...	...	...	...	rrr
,, *octaëdricum*, (Reinsch) Hansg.	...	rrr	rrr									
Dictyosphærium pulchellum, Wood	...	...	rrr	rrr	rr	r	...	...	...	rr	rrr	
Glœocystis gigas, (Kütz.) Lagerh.	rr	r	...	...	...	...	...	...	...	...	c	r
,, *vesiculosa*, Näg.	...	rrr	...	...	...	...	...	...	...	...	rrr	
,, *infusionum*, (Schrank) W. & G. S. West	...	...	...	...	...	...	...	...	...	...	...	rrr
Sphærocystis Schroeteri, Chodat	...	...	...	...	...	...	...	...	...	...	c	c
Schizochlamys gelatinosa, A. Br.	...	...	rr									

TABLE OF LITTORAL ALGA-FLORA (*continued*).

SPECIES.	1905.											1906.
	Feb. 4th.	Mar. 4th.	Apr. 1st.	May 6th.	June 3rd.	July 1st.	Aug. 5th.	Sept. 2nd.	Oct. 7th.	Nov. 4th.	Dec. 2nd.	Jan. 6th.
Bacillarieæ.												
Melosira granulata, Ralfs	...	c	...	...	r	...	rr	...	...	...	rrr	rr
Cyclotella Meneghiniana, Kütz.	...	...	...	...	...	...	c	rr				
„ *stelligera*, Cleve & Grun.	...	...	...	...	...	...	rrr	...	...	...	r	rr
Tabellaria flocculosa, (Roth) Kütz.	c	r	rr	r	...	...	r	ccc	...	cc	cc	ccc
Diatoma elongatum, Ag.	...	...	...	...	...	...	...	rr				
Synedra Ulna, (Nitzsch) Ehrenb.	rr	rr	...	...	rr	r	...	r	...	...	...	c
„ *Acus* (Kütz.) Grun.	rr	r	...	...	r	c	c	...	...	cc	c	rr
Eunotia major, (W. Sm.) Rabenh., var. *bidens*, (Greg.) Van Heurck	rr	rr	...	...	...	rr	c	...	...	...	...	rrr
„ *gracilis*, (Ehrenb.) Rabenh.	...	...	...	...	...	...	...	...	...	...	rr	
„ *crispula*, sp. n.	...	rrr	...	...	rr							
„ *lunaris*, (Ehrenb.) Grun.	...	...	...	...	...	...	r	...	...	c	r	r
Achnanthes linearis, W. Sm.	...	...	...	...	...	c						
Cocconeis Placentula, Ehrenb.	r	cc	c	c	cc	c	r	...	rr	...	...	rrr
Navicula major, Kütz.	rr	r	r	...	rr	...	r	...	...	...	rrr	
„ *viridis*, Kütz.	...	...	...	...	rrr							
„ *cardinalis*, Ehrenb.	...	...	...	...	...	...	...	...	...	...	rr	
„ *borealis*, (Ehrenb.) Kütz.	...	...	...	...	...	...	rrr					
„ *bicapitata*, Lagerstedt, var.	...	r	...	rr	...	...	r	...	...	r	...	rrr
„ *mesolepta*, Ehrenb., var.	...	...	...	...	...	...	rr					
„ *radiosa*, Kutz., var. *acuta*, (W. Sm.) Van Heurck	...	rr	r	r	r	c	cc	rr				
„ „ var. *tenella*, (Bréb.) Van Heurck	...	...	...	r	r	r	c					
Stauroneis Phœnicenteron, Ehrenb.	...	rr	...	...	rrr	...	r					
„ *anceps*, Ehrenb.	...	...	...	...	rrr							
Vanheurckia rhomboides, (Ehrenb.) Bréb.	...	...	...	...	...	rr	rrr					
„ *viridula*, Bréb.	c	cc	c	c	cc	cc	cc	rrr	ccc	r	c	c
Gyrosigma attenuatum, (Kütz.) Rabenh., forma	...	...	...	...	rr							
Gomphonema gracile, Ehrenb.	...	...	...	...	...	...	...	...	...	...	rr	r
Cocconema lanceolatum, Ehrenb.	...	...	...	...	rr	r						

Cocconema ventricosum, (Kütz.) G. S. West	...	...	...	...	...	...	rr					
„ *gracile*, (Rabenh.) G. S. West	rr	r	r	r	r	c	cc	r	...	...	...	rrr
Epithemia turgida, (Ehrenb.) Kütz.	...	rr	rrr									
„ *Sorex*, Kütz.	...	rrr										
Rhopalodia gibba (Kütz.) O. Müll.	...	rrr	rrr	rr	rrr							
Nitzschia Palea, (Kütz.) W. Sm.	rr	r	r	r	r	c	cc	...	...	...	...	rr
„ *Sigma*, (Kütz.) W. Sm.	...	rrr	...	...	rr	rr	rr	...	...	rr		
„ *curvula*, (Ehrenb.) W. Sm.	...	rr										
„ *vermicularis*, (Kütz.) Grun.	...	...	...	...	...	r	r					
Hantzschia Amphioxys, (Ehrenb.) Grun.	...	...	...	...	...	...	...	...	...	...	rrr	
Surirella robusta, Ehrenb.	...	rr	r	...	...	rr	rr					
„ „ var. *splendida*, (Ehrenb.) Van Heurck	...	...	rr	rr	rr	r						
„ *linearis*, W. Sm.	...	...	...	...	rrr							

Myxophyceæ.

Glaucocystis Nostochinearum, Itzigsh.	...	...	rr									
Anabæna sp. (sterile)	...	r	c	c	rr	rr						
Rivularia sp. (fragmentary)	...	rr	r									
Lyngbya perelegans, Lemm.	rrr	rr	r	r	...	...	...	...	...	...	r	rrr
Oscillatoria tenuis, Ag.	...	...	rrr	rrr	rr							
„ *Agardhii*, Gom.	...	...	...	...	...	cc						
Glæothece linearis, Näg.	rrr	rr										
Tetrapedia Reinschiana, Arch.	...	...	...	...	...	rr	...	...	...	...	rr	
Gomphosphæria lacustris, Chodat	...	...	...	...	...	r	...	...	...	...	...	rrr
Chroococcus minimus, (Keissler) Lemm.	rrr	rrr										

Peridinieæ.

Glenodinium cinctum, Ehrenb.	...	...	...	...	...	...	...	...	...	...	rr	
Peridinium inconspicuum, Lemm.	...	...	...	...	...	...	...	...	...	r	cc	r
„ *Volzii*, Lemm., var. *australe*, var. n.	...	...	...	rrr	...	...	...	...	...	...	rrr	

Flagellata.

Dinobryon cylindricum, Imhof	...	...	...	...	...	...	...	...	...	r	r	
„ „ var. *divergens*, (Imhof) Lemm.	...	...	...	...	...	...	...	...	...	...	c	rrr
„ *elegantissimum*, sp. n.	...	...	...	...	...	...	...	...	...	...	...	rrr
„ *protuberans*, Lemm.	...	...	...	...	...	...	...	...	...	...	rr	
„ *elongatum*, Imhof, var. *undulatum*, Lemm.	...	...	...	...	...	...	...	...	...	...	...	rrr

DOMINANT FORMS AND THEIR PERIODICITY.

Flagellata.—The genus *Dinobryon* was not so abundant as in the plankton, although *D. cylindricum* var. *divergens* was common in December. *D. elegantissimum* is an interesting stipitate form which was very scarce in January. *Trachelomonas hispida* occurred sparingly several times during the year.

Peridinieæ.—Two species occurred in the warmer part of the year, but only one, *P. inconspicuum*, was abundant, occurring in quantity in December. *P. Volzii* var. *australe* was observed very sparingly in both May and December, months in which the temperature was approximately the same.

Chlorophyceæ.—From February to July the Desmids were the dominant feature of the benthos, and they attained their maximum abundance in April, with a water-temperature of 17·8° C. In August (temp. 10° C.) they disappear with remarkable abruptness, the collections for this month containing thousands of the dead and decaying remains of these plants. Very few individuals persisted until the end of August, and in September, which is the last month of the cold period, Chlorophyceæ of all kinds were entirely absent. In October a few Desmids are again noticeable, and during the rise of temperature through November and December vast numbers of the smaller species make their appearance, amongst which should be specially mentioned *Euastrum Turneri* forma *minor*, *Cosmarium Capitulum* var. *australe*, *C. quadratulum*, *C. pygmæum*, *C. angulosum*, *Staurastrum bibrachiatum* var. *cymatium*, *S. tetracerum*, and a form of *S. excavatum*. Although the number of species (67) of Desmids present in the early part of the warm season, from November to December, is almost as great as the number (81) occurring during the autumn, from May to July, they do not give such a pronounced character to the collections. This is entirely due to the dominance of smaller and more inconspicuous species during the vernal period, as compared with larger and more ostentatious species which predominate in the autumnal period.

In November, and also to a less extent in December, the Zygnemaceæ and Oedogoniaceæ are dominant, and almost all in the fruiting condition. *The commencement of the fructiferous state simultaneously with a rising temperature is strictly comparable with what occurs in the southern and south-western counties of England.* I have observed repeatedly in Surrey and Hampshire, and more especially has it been brought to my notice in Devonshire and Cornwall, that the normal period of fructification in the Zygnemaceæ and the Oedogoniaceæ begins at or towards the end of April, and continues through May into June. With regard to thirteen species of the genus *Spirogyra*, Fritsch & Rich * have recently brought forward observations to show that zygospore-formation normally takes place during the vernal phase of their life-history.

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* F. E. Fritsch & F. Rich in Ann. Bot. xxi. (July 1907) pp. 432 & 436.

Five species of *Mougeotia* were observed with spores, one, *M. viridis*, in October, and the other four in November. This is again strictly comparable with the conditions under which fruiting takes place in the British Islands. Especially interesting is the first production of spores by *Mougeotia viridis*. In the British Islands this is almost invariably the first species of the genus to enter into the fructiferous condition in the spring. It begins its spore-formation in the Midlands and the Southern countries in March, with a water-temperature of 5°–7° C.; and in the more mountainous areas of the Pennine Chain, the English Lake District, and North Wales, fructification commences in April or May according to the state of the weather.

Fig. 5.

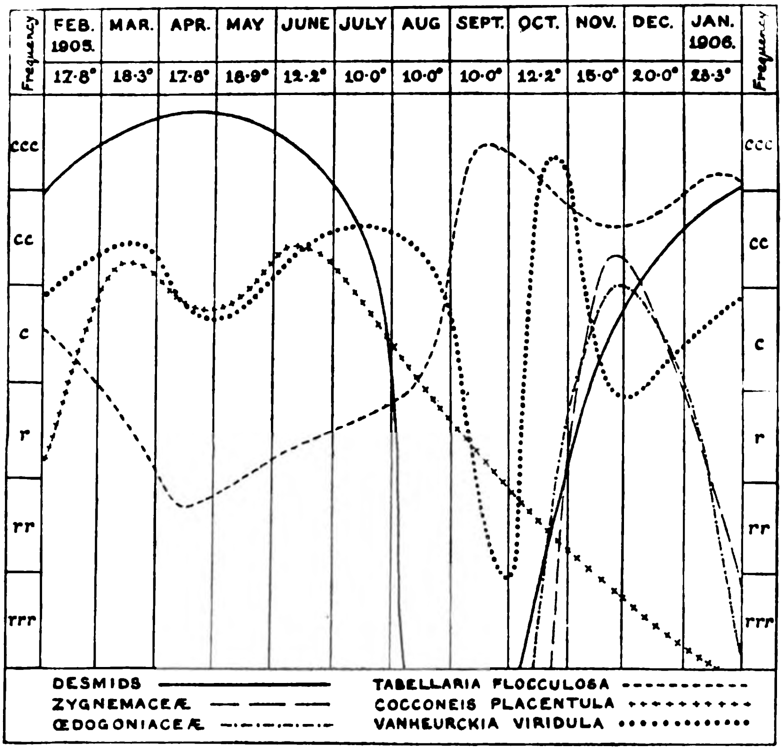

Chart showing the periodicity of some of the more important Chlorophyceæ and Diatoms of the Yan Yean littoral region.

It must be distinctly understood that this period of spore-formation is not necessarily the period of maximum vegetative growth of the species, which varies much according to conditions of environment. In the upland

and subalpine lakes and tarns of the British Islands, in which species of *Mougeotia* and *Zygnema* abound, the maximum vegetative abundance usually occurs in the late summer and early autumn as the temperature is gradually declining*. In these habitats spores are only rarely produced, the winter season being passed in the form of "cysts" †.

Only two species of the numerous Desmids of these weedy shores were observed with zygospores, namely, *Cosmarium contractum* var. *ellipsoideum* in March, and *Cylindrocystis diplospora* in April. I do not think this is at all remarkable, notwithstanding the abundance of Desmids in the littoral region of the Yan Yean, and it is entirely in accordance with numerous observations I have made in the British Islands. The occurrence of zygospores in the Desmidiaceæ appears to be very spasmodic, and the conditions which result in their production are apparently both local and special. I have collected and examined, during an extended study of the group, large numbers of the zygospores of Desmids, and have kept a careful record of all the species which have come under my notice in a fruiting condition. Only two points are manifest on a study of these records: first, that zygospores are not produced in the colder period of the year; and secondly, that they are more frequently formed in small pools, ponds, and ditches than in large bodies of water such as lakes. This is doubtless owing to the greater ease with which the necessary conditions may be attained in the smaller bodies of water. In no single instance have I known of the formation of Desmid-zygospores owing to impending drying-up of the pools, because, as a rule, Desmids only occur in permanent pools which are scarcely liable to be dried up. Many Desmids produce zygospores in spring, with a rising temperature, and many (perhaps the majority) in the late summer just after the maximum temperature. Zygospore-formation can be observed in stagnant pools and ditches in which there is practically no aëration of the water; it can also take place at the margins of lakes or in ditches with slowly flowing water, in which the aëration of the water is fairly good; and it also occurs on dripping rocks in which the conditions of aëration are at their maximum. Sometimes a species produces zygospores in abundance in one *Sphagnum*-pool, but in another adjacent pool, in which the same species is equally abundant, no zygospores are formed, although the individuals are apparently under precisely the same conditions. On the whole, we are at present almost entirely in the dark concerning the physiological conditions which result in zygospore-formation in the Desmidiaceæ. The precise conditions are probably widely different for various species of Desmids, owing to the great differences in the normal habitats of these plants.

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* In the littoral Alga-flora of the alpine lakes of the Pike's Peak region, Colorado, species of *Zygnema* and *Mougeotia* reach their maximum abundance in September, when the temperature is falling. *Cf.* Shantz, in Trans. Amer. Micr. Soc. xxvii. (March 1907) pp. 92 & 93.

† G. S. West, Treatise Brit. Freshw. Alg. (1904) pp. 115 & 121. The survival through the winter of many species of the Zygnemaceæ (but especially species of *Mougeotia*) by means of these resting "cysts" is much commoner than is imagined, and it occurs in lowland areas almost to the same extent as it does in the upland districts. I have found it to occur commonly in the English Midlands in ditches and *Sphagnum*-pools which I have had under continuous monthly observation for two years. Similar "cysts" occur frequently in *Ulothrix* and in *Rhizoclonium*. Each "cyst" consists of one or several vegetative cells which have entered into a period of quiescence or inactivity, after having developed rather thicker cell-walls. Sometimes a gelatinous envelope is also evident.

Species of the Protococcoideæ never appear to become a dominant feature of the benthos, and few of them can even be regarded as common. Some species are represented all through the year except in September and October, and the greatest variety of forms occurs in December and January.

Bacillarieæ.—*Melosira granulata* is common in March, but is otherwise scarce. *Tabellaria flocculosa* is very common in September, at a time when all other Algæ (including Diatoms) are exceedingly scarce. This species maintains its abundance until January, thus having its maximum period during the vernal rise of temperature (10°–23·3° C.). On the other hand, *Cocconeis Placentula* (free-floating and unattached) is very common from March to July, after which it gradually decreases in abundance. This species therefore attains its maximum during the autumnal fall of temperature (18·3°–10° C.). *Vanheurckia viridula* is one of the most conspicuous Diatoms of the Yan Yean benthos, being common nearly all the year round. It has a minimum period towards the end of September, which is followed very rapidly by a great maximum in October. For the complete annual periodicity of these Diatoms consult the chart (text-fig. 5, p. 33).

Myxophyceæ.—As in the plankton there are very few Blue-green Algæ in the benthos. One species of *Anabæna* occurred from March to July, being most abundant in April and May, but in 1905 it produced no spores. *Oscillatoria Agardhii* was common in July, but did not occur in any other month.

III. THE ALGÆ OF THE YAN YEAN DRAINAGE AREA.

Pools in the Yan Yean Catchment Basin.

Two pools were examined. The first one was a shallow grassy pool from which collections were made in October, 1905. The material consisted of Chlorophyceæ and Diatoms, and three species occurred in quantity. These were *Rhizoclonium hieroglyphicum*, Kütz., *Ulothrix subtilis*, Kütz., and *Spirogyra porticalis*, (Vauch.) Cleve, the latter in the fruiting condition. Among these three dominant species the following were observed :—

Chlorophyceæ.—*Bulbochæte* sp. (sterile), *Oedogonium pisanum*, Wittr. (in the fruiting condition), *O. victoriense*, G. S. West (in the fruiting condition), *Pleurotænium Ehrenbergii*, (Bréb.) De Bary (several forms), *P. truncatum*, (Bréb.) Näg., *Euastrum Turnerii*, West, *Cosmarium tinctum*, Ralfs, *C. granatum*, Bréb., *Staurastrum hexacerum*, (Ehrenb.) Wittr., *S. asperum*, Bréb. (small form), *Hyalotheca dissiliens*, (W. Sm.) Bréb., and *Eremosphæra viridis*, De Bary.

Bacillarieæ.—*Eunotia pectinalis*, (Dillw.) Rabenh., *E. major*, (W. Sm.) Rabenh. var. *bidens*, (Greg.) Van Heurck, *E. lunaris*, (Ehrenb.) Grun., *Cocconeis Placentula*, Ehrenb., *Navicula viridis*, Kütz., *Gomphonema intricatum*, Kütz., *Nitzschia Palea*, (Kütz.) W. Sm., *N. sigmoidea*, (Ehrenb.) W. Sm., *Hantzschia Amphioxys*, (Ehrenb.) Grun.

The collections from the second pool were all made in September, 1907, and consisted almost entirely of Chlorophyceæ. The dominating species were all Desmids, some of them being present in quantity. Diatoms were entirely absent. The following species were observed :—

Chlorophyceæ.—Sterile spp. of *Bulbochæte* and *Oedogonium*, *Coleochæte scutata*, Bréb. (with oogonia and antheridia), *Mougeotia* sp. (sterile), *Radiofilum conjunctivum*, Schmidle, *Closterium Cornu*, Ehrenb., *C. setaceum*, Ehrenb., *Triploceras gracile*, Bail. (very abundant; several varieties), *Euastrum Turnerii*, West, forma, *E. denticulatum*, (Kirchn.) F. Gay, *Cosmarium Regnesi*, Reinsch, *C. impressulum*, Elfv., *C. venustum*, (Bréb.) Arch., var. *induratum*, Nordst., *C. quadratulum*, (F. Gay) De Toni, *C. pygmæum*, Arch., *C. pseudoprotuberans*, Kirchn., *C. contractum*, Kirchn., var. *ellipsoideum*, (Elfv.) W. & G. S. West, *C. amplum*, Nordst. (very abundant), *Staurastrum dejectum*, Bréb., *S. alternans*, Bréb., *S. cyrtocerum*, Bréb., *S. neglectum*, sp. n., *S. excavatum*, W. & G. S. West, *S. tetracerum*, Ralfs, *S. longiradiatum*, W. & G. S. West, *S. zonatum*, Börges., *S. sagittarium*, Nordst., *S. sexangulare*, (Buln.) Rabenh. (abundant), *Desmidium Baileyi*, (Ralfs) Nordst., *Sphærozosma Aubertianum*, West, *Spondylosium papillosum*, W. & G. S. West, *Hyalotheca dissiliens*, (W. Sm.) Bréb., *Characium longipes*, Rabenh., *Tetraëdron minimum*, (A. Br.) Hansg., *T. gigas*, (Wittr.) Hansg. (diam. 72–78 μ), *Ankistrodesmus falcatus*, (Corda) Ralfs, var. *acicularis*, (A. Br.) G. S. West, *Kirchneriella obesa*, W. & G. S. West, and *Glœocystis gigas*, (Kütz.) Lagerh.

Myxophyceæ.—*Merismopedia glauca*, (Ehrenb.) Näg.

Peridinieæ.—*Peridinium inconspicuum*, Lemm.

SMALL POOLS, HONEYSUCKLE FLAT.

These were a series of small "saucer-holes" only a few feet across and very shallow. The water becomes warmed up almost to a tepid condition in the sun, and the pools dry up in the warmest weather. The collections were made in September 1907, and contained the following species :—

Chlorophyceæ.—*Ulothrix idiospora*, sp. n. (with a seriate development of akinetes), *Zygnema leiospermum*, De Bary (in small quantity but in a fructiferous state).

Heterokontæ.—*Tribonema bombycina*, (Ag.) Derb. & Sol., forma *minor*, (Wille) G. S. West, *Ophiocytium majus*, Näg.

Bacillarieæ.—*Eunotia lunaris*, (Ehrenb.) Grun., *Navicula bicapitata*, Lagerst., *Gomphonema gracile*, Ehrenb., *Nitzschia Sigma*, (Kütz.) W. Sm.

Myxophyceæ.—*Oscillatoria Agardhii*, Gom.

All the above species, except those belonging to the Heterokontæ, have been derived from the Yan Yean Reservoir by the overflow of the waters during times of heavy rain. Species of the genus *Ophiocytium* thrive in pools which become stagnant and foul in hot weather. They appear to flourish best where there is little aëration of the water *. The dominant species of the pools were *Ulothrix idiospora* and the small form of *Tribonema bombycina*.

SMALL POOLS IN RANA CREEK.

The collections were made in September 1907, and the dominating Algæ were *Zygnema* sp. (sterile ; filaments very thick) and *Chætophora elegans*, (Roth) Ag. The others noticed were *Volvox globator*, (L.) Ehrenb., *Characium tenue*, Herm., *Navicula bicapitata*, Lagerst., *N. radiosa*, Kütz., var. *acuta*, (W. Sm.) Van Heurck, *Gomphonema gracile*, Ehrenb., and its var. *dichotomum*, (Kütz.) Van Heurck, *Nitzschia Palea*, (Kütz.) W. Sm., and *Chamæsiphon confervicola*, A. Br. The latter was attached thickly to the leaves of *Myriophyllum*.

POOLS IN OTTELIA CREEK.

Two pools of very different character were examined in September 1907. The first one was a stagnant pool dominated by *Tribonema bombycina*, (Ag.) Derb. & Sol., forma *minor*, *Ophiocytium parvulum*, (Perty) A. Br., *O. capitatum*, Wolle, and *Microthamnion Kützingianum*, Näg. The two species of *Ophiocytium* are well-known inhabitants of small stagnant pools; *Tribonema bombycina* f. *minor* thrives best in water which is fairly well aërated, but also often occurs in stagnant pools ; *Microthamnion Kützingianum* generally occurs in small pools, not necessarily stagnant, and it is a decided vernal type. In the British Islands it is seen at its best in April and May. Among the species mentioned were small quantities of the following :—

Chlorophyceæ.—*Oedogonium* sp. (with developing oogonia), *Oe. cryptoporum*, Wittr., *Zygnema* sp. (sterile), *Spirogyra quadrata*, (Hass.) Petit (in the fruiting condition), *Closterium Venus*, Kütz., *Pleurotænium truncatum*, (Bréb.) Näg., *Cœlastrum sphæricum*, Näg., *Ankistrodesmus falcatus*, (Corda) Ralfs.

Bacillarieæ.—*Eunotia lunaris*, (Ehrenb.) Grun., *Navicula bicapitata*,

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* Consult also F. E. Fritsch in Ann. Bot. xxi. (1907) pp. 256 & 257; Fritsch gives a summary of the records of *Ophiocytium* (up to 1906) in tropical pools.

Lagerst., *Navicula gibba,* (Ehrenb.) Kütz., *N. major*, Kütz., *N. appendiculata*, (Ag.) Kütz., *N. Iridis,* Ehrenb., var. *affinis*, (Ehrenb.) Van Heurck, *Gomphonema gracile,* Ehrenb., *G. tenellum*, Kütz., *Nitzschia Palea,* (Kütz.) W. Sm.

The second pool was not stagnant, and really formed a part of the boggy or marshy stream which drains Ottelia Creek into the Yan Yean Reservoir. The Algæ were mostly Chlorophyceæ and largely Desmids. The following species were observed :—

Chlorophyceæ.—*Oedogonium undulatum,* (Bréb.) A. Br. (sterile), *Coleochæte irregularis*, Pringsh., *Ulothrix idiospora*, sp. n., *Radiofilum conjunctivum*, Schmidle, *Triploceras gracile*, Bail., var. *robustum* var. n., *Euastrum ansatum*, Ralfs, *E. Turneri*, West, *Cosmarium obsoletum,* (Hantzsch) Reinsch, var. *sitvense*, Gutw., *C. granatum*, Bréb., *C. pseudoprotuberans*, Kirchn., *C. bireme*, Nordst., *C. Regnesi*, Reinsch, *C. quadratulum*, (F. Gay) De Toni, *C. venustum*, (Bréb.) Arch., var. *induratum*, Nordst., *C. impressulum*, Elfv., forma *suborthogona* (Racib.) nob. (= *C. suborthogonum*, Racib.), *C. sphalerostichum*, Nordst., *C. Blyttii*, Wille, *C. amœnum*, Bréb., var. *mediolæve*, Nordst., *Staurastrum Hardyi*, sp. n., *S. orbiculare*, Ralfs, var. *depressum*, Roy & Biss., *S. dilatatum*, Ehrenb., var. *obtusilobum*, De Not., *S. striolatum*, (Näg.) Arch. (with zygospores), *Onychonema filiforme*, (Ehrenb.) Roy & Biss., *Pediastrum Tetras*, (Ehrenb.) Ralfs, *Scenedesmus acutiformis*, Schröder, *Dictyosphærium pulchellum*, Wood, *Glœocystis gigas*, (Kütz) Lagerh., var. *maxima*, West.

Bacillarieæ.—*Tabellaria flocculosa*, (Roth) Kütz., *Synedra Ulna*, (Nitzsch) Ehrenb., *Navicula major*, Kütz., *N. radiosa*, Kütz., *Vanheurckia rhomboides*, (Ehrenb.) Bréb., *Cocconema gracile,* (Rabenh.) G. S. West.

Myxophyceæ.—*Anabæna* sp. (sterile).

TOOROURONG RESERVOIR.

I. *Plankton*.—This was collected by boat on July 25th, 1907, along a course clear of weeds. The material contained large quantities of decaying organic matter and fine sand, mixed chiefly with Diatoms, and is of particular interest in comparison with the plankton of the Yan Yean. *Ceratium Hirundinella* was not uncommon although quite absent from the Yan Yean, and a beautiful new variety (var. *pulcherrima*) of *Micrasterias Thomasiana* was also frequent. The most interesting Diatom was *Gyrosigma distortum* var. *Parkeri*, and the frustules of *Vanheurckia rhomboides* reached a large size (135 μ in length). The following were the species observed :—

Chlorophyceæ.—Fragments of *Oedogonium* sp. and *Microspora* sp., *Closterium Venus*, Kütz., *Micrasterias Thomasiana*, Arch., var. *pulcherrima* var. n.

Bacillarieæ.—*Tabellaria flocculosa*, (Roth) Kütz., *Synedra Ulna*, (Nitzsch) Ehrenb., *Fragilaria crotonensis*, (A. M.-Edw.) Kitton, *Eunotia pectinalis,* (Dillw.) Rabenh., *E. crispula*, sp. n., *Navicula cardinalis*, Ehrenb., *N. gracilis*, Kütz., *N. gibba*, (Ehrenb.) Kütz., *N. viridis*, Kütz., *N. Brébissonii*, Kütz., *N. rhynchocephala*, Kütz., *Vanheurckia rhomboides*, (Ehrenb.) Bréb., *Gyrosigma distortum*, W. Sm., var. *Parkeri*, (Harris.) Cleve, *Gomphonema gracile*, Ehrenb., *Cocconema cuspidatum*, (Kütz.) G. S. West, *Surirella robusta*, Ehrenb., var. *splendida*, (Ehrenb.) Van Heurck, *S. biseriata*, Bréb., *S. linearis*, W. Sm.

Myxophyceæ.—*Oscillatoria* sp. (fragmentary; probably *O. Agardhii*, Gom.).

Peridinieæ.—*Ceratium Hirundinella*, O. F. Müll. The forms were slightly different from any others I have seen. The second antapical horn was almost as long as the first one, and the third was of good length and curved inwards. (Pl. 2. fig. 15.)

II. *Littoral Algæ.*—The weeds at the margins of the reservoir were mostly *Eleocharis sphacelata*, R. Br., and a species of rush. Like the plankton the weed-collections were almost entirely Diatomaceous. The greater part of the material consisted of immense quantities of *Tabellaria flocculosa* and *Navicula gracilis*, amongst which the following species were observed rather sparingly :—

Chlorophyceæ.—Sterile species of *Oedogonium*, *Mougeotia*, and *Zygnema*, *Closterium Venus*, Kütz., *Cosmarium angulosum*, Bréb., *C. Regnellii*, Wille, *C. impressulum*, Elfv., forma *suborthogona*, (Racib.) nob., *Staurastrum pygmæum*, Bréb.

Bacillarieæ.—*Synedra Ulna*, (Nitzsch) Ehrenb., *S. Acus*, (Kütz.) Grun., *Achnanthes linearis*, W. Sm., *Navicula major*, Kütz., *N. gibba*, (Ehrenb.) Kütz., *N. Iridis*, Ehrenb., *N. dicephala*, Ehrenb., *N. exilis*, (Kütz.), Grun., *Gomphonema gracile*, Ehrenb., *Cocconema gracile*, (Rabenh.) G. S. West, *Nitzschia Palea*, (Kütz.) W. Sm.

WALLABY CREEK WEIR.

Plankton collections were obtained from the outlet by allowing the outflowing current to pass through the net for about twenty minutes at a time. The material contained a vast amount of organic matter and a quantity of fine sand. No predominating species were noticeable, but the following were observed :—

Chlorophyceæ.—Sterile species of *Oedogonium*, *Mougeotia*, *Zygnema*, and *Spirogyra*, *Closterium prælongum*, Bréb., forma *brevior*, West, *C. Ulna*, Focke (very elongated form; long. 675 μ, lat. 20 μ), *Penium margaritaceum*, Ehrenb., var. *irregularius*, W. & G. S. West, *Cosmarium trachypleurum*, Lund., var. *subglabrum* var. n., *Tetraspora lacustris*, Lemm.

Heterokontæ.—*Tribonema bombycina*, (Ag.) Derb. & Sol., forma *minor*.

Bacillarieæ.—*Tabellaria flocculosa*, (Roth) Kütz., *Synedra Ulna*, (Nitzsch) Ehrenb., *Navicula radiosa*. Kütz., *Vanheurckia rhomboides*, (Ehrenb.) Bréb., *V. viridula*, Bréb., *Gomphonema gracile*, Ehrenb., *Surirella linearis*, W. Sm.

Myxophyceæ.—*Oscillatoria irrigua*, Kütz.

A small collection from amongst wet mosses on the Wallaby watershed yielded the following :—*Mougeotia* sp., *Netrium Digitus*, (Ehrenb.) Itzigs. & Rothe, *Navicula viridis*, Kütz., *N. bicapitata*, Lagerst., *Vanheurckia rhomboides*, (Ehrenb.) Bréb., *V. viridula*, Bréb., *Achnanthes coarctata*, Bréb., *Surirella linearis*, W. Sm.

SILVER CREEK WEIR.

Samples of plankton were obtained both from the outlet and from alongside the stone embankment of the dam. As in the case of the material collected from Wallaby Creek Weir, an enormous amount of decaying organic matter was present, amongst which were numerous sporangia of ferns and fragments of Bryophytes. The dominant algal constituent was *Synedra Ulna*, and the following were also present in smaller quantity :—

Chlorophyceæ.—*Closterium prælongum*, Bréb., forma *brevior*, West.

Bacillarieæ.—*Melosira granulata*, Ralfs, *Eunotia major*, (W. Sm.) Rabenh., var. *bidens*, (Greg.) Van Heurck, *Tabellaria flocculosa*, (Roth) Kütz., *Navicula Brébissonii*, Kütz., *Vanheurckia rhomboides*, (Ehrenb.) Bréb., *V. vulgaris*, (Thw.) Van Heurck, *Surirella robusta*, Ehrenb., var. *splendida*, (Ehrenb.) Van Heurck, *S. linearis*, W. Sm.

Myxophyceæ.—*Oscillatoria irrigua*, Kütz.

In the channel above the weir, *Tribonema bombycinum* forma *minor* occurred in quantity along with *Synedra Ulna*.

The Wallaby and Silver Creek collections were made in July, 1907.

IV. THE RELATIONS BETWEEN THE PLANKTON, BENTHOS, AND ALGÆ OF THE DRAINAGE AREA.

The phytoplankton of the Yan Yean Reservoir, in the thirteen months from Feb. 1905 to Feb. 1906, contained 104 species and 16 varieties. During the same period 206 species and 17 varieties were observed in the microphytic benthos. Of these Algæ, 79 *species and* 6 *varieties were common to both plankton and benthos*, and 23 *species and* 5 *varieties were exclusively confined to the plankton*. Of the latter, the following species and varieties are *true plankton-forms* :—

Closterium Kützingii, *Cosmarium tortum* forma *trigona*, *Staurastrum muticum* var. *victoriense*, *S. lævispinum* var. *subbrachiatum*, *S. patens* var. *planctonicum*, *S. paradoxum* var. *longipes*, *Pediastrum duplex* var. *clathratum*, *Closteriopsis longissima*, *Kirchneriella lunaris*, *Oocystis lacustris*, *O. parva*, *Lagerheimia splendens*, *Botryococcus Braunii*, *Melosira granulata* var. *spinosa*, *Rhizosolenia morsa*, *Gyrosigma elongatum* var., *Chroococcus limneticus* var. *subsalsus*, and *Dinobryon elongatum* var. *undulatum*.

Some species, although present in both the plankton and the benthos, are so much more abundant in the former that they also must be regarded as true plankton-forms. Such are:—*Pleurotænium mamillatum*, *Micrasterias Hardyi*, *Cosmarium Hardyi*, *Staurastrum mucronatum* var. *delicatulum*, *Melosira granulata*, *Peridinium Volzii* var. *australe*, *Dinobryon cylindricum* and its var. *divergens*. To these may be added *Staurastrum longiradiatum*, *Volvox aureus*, and *Eudorina elegans*.

A few species, such as *Cosmarium perfissum*, *C. achondroides*, *C. contractum* and its var. *ellipsoideum*, are equally common in both plankton and benthos, thriving both in the comparative shelter of the weedy margins and in the more disturbed limnetic region of the lake. *Staurastrum victoriense* was present in small quantity in the plankton all the year round, but in the littoral region it only occurred from April to July, reaching a maximum in the latter month and disappearing immediately afterwards.

Quite a number of species occur in the drainage area, and even in the catchment basin, which have not been found either in the plankton or the littoral region of the Yan Yean. In the case of certain species this is rather remarkable, as they occur in quantity in small pools within a few yards of the reservoir yet not in any part of the lake itself. Of these species, *Radiofilum conjunctivum*, *Pleurotænium truncatum*, *Cosmarium amplum*, and *Staurastrum zonatum* are the most noteworthy, and they afford a direct contrast to the 23 species exclusively confined to the plankton.

In comparison with the phytoplankton of the Yan Yean Reservoir, that of the Toorourong Reservoir and of the Wallaby and Silver Creek Weirs is almost insignificant. Compared with the 104 species constituting the phytoplankton of the Yan Yean, 24 occurred in the Toorourong, 18 in Wallaby Creek Weir, and only 11 in Silver Creek Weir. Most of the plankton of these upper dams consists of decaying organic matter and fine sand, and the meagreness of the phytoplankton is due to the constant agitation and continual renewal of the water *. Most of the constituents are Diatoms, and the number of species gradually decreases as the disturbance of the water becomes greater owing to the diminished size of the reservoirs. The few species of Chlorophyceæ were principally Desmids, but they were of quite a distinct character from those found in the Yan Yean. The most noticeable feature among the Diatoms was the large size attained by the frustules of *Vanheurckia rhomboides*.

The algal investigation of the upper dams shows clearly that the Yan Yean Reservoir does not receive any of its characteristic algal constituents from these sources, even though six-sevenths of its total water-supply comes along the aqueduct from the Toorourong, having been derived from the large drainage area tapped by these upper reservoirs. We have, therefore, to turn next to the Yan Yean catchment basin for information concerning the source of the rich and varied assortment of Algæ constituting the phytoplankton and microphytic benthos of the Yan Yean. It is along the boggy inlets of Rana and Ottelia Creeks that one finds a rich Alga-flora such as would be able to furnish the microphytic benthos, and also the plankton, with some of their characteristic species. It seems highly probable that many of the species of the littoral region are recruited by means of individuals carried into the lake with the slow drainage from these two boggy creeks, and that in turn the plankton receives recruits of certain of these species from the littoral region.

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* *Cf.* also H. L. Shantz, "Prelim. Report on the Biol. Study of the Lakes of the Pike's Peak Region," Trans. Amer. Micr. Soc., March 1907, p. 91.

Some of the species common to both the plankton and the benthos reach their maximum development in the plankton (Feb.–April) some time before they attain their maximum abundance (May–June) in the benthos. In this respect, *Cosmarium contractum* (and its var. *ellipsoideum*), *Staurastrum corniculatum* (and its var. *spinigerum*), *S. muticum*, *S. leptacanthum*, and *Oscillatoria Agardhii* are particularly noticeable. These species after practically disappearing from the plankton, reappear in the littoral region, and under the new conditions attain a second maximum. Thus during the fall of temperature in the early autumnal period the microphytic benthos obtains some of its constituents from the plankton.

Turning now to a consideration of the phytoplankton, many of the species are without doubt derived from the microphytic benthos, and some of them thrive as well under limnetic conditions as they do among the weeds at the shores. The chief interest centres around the 23 species and 5 varieties exclusively confined to the plankton, and the few others which are so much more abundant in the limnetic region than elsewhere. Whence did they originate? Some of them have most probably been derived from the littoral region, and finding the conditions of plankton-existence eminently suitable, have thrived to an unprecedented degree. Some have in consequence become dominant features of the plankton throughout the greater part of the year, whereas either they cannot be detected at all in the littoral region, or the most diligent search fails to reveal more than very few isolated individuals. *Micrasterias Hardyi* is a case in point. This Desmid is the rarest of casuals among the weeds of the littoral region, but it is the most conspicuous and dominating species of the phytoplankton throughout the entire year. It most likely had an origin from a littoral or even from a bog-species, and the great development of its outstanding lobes at once distinguishes it from any of its bog or swamp relatives. This feature has most certainly been developed as a result of adaptation to a limnetic existence, as the outstanding lobes materially increase the floating capacity of the individual. The occurrence of *Micrasterias Hardyi* in the benthos is merely accidental, and the only clue to the original species from which it has been derived is such as is furnished by its morphological peculiarities. These point most decidedly to some form of *Micrasterias mahabuleshwarensis* as being the ancestor of *Micrasterias Hardyi*, and this is further confirmed by the occurrence of *M. mahabuleshwarensis* in the bogs and swamps of several parts of Victoria.

With regard to species such as *Rhizosolenia morsa*, *Lagerheimia splendens*, and others, there is no definite information as to how they have obtained a footing in the plankton. Much more investigation is yet required concerning the formation of resting-spores in these Algæ, the resistance of such spores to desiccation, and the possibilities of transport by means of water-fowl such as abound on the Yan Yean Reservoir.

V. SYSTEMATIC ACCOUNT OF THE MORE NOTEWORTHY SPECIES.

The first systematic account of importance dealing with the freshwater Algæ of the Australasian region was by Nordstedt in 1888[1]. In this work the author described and figured with great care a number of Algæ (especially Desmids) which are more or less peculiar to this region of the earth. Very few of the species were Australian, the great majority being from New Zealand, the Alga-flora of which country had already been partially investigated by Spencer[2] and also by Maskell[3].

Other contributions to the Alga-flora of Australia have since appeared by Raciborski[4], Moebius[5], Schmidle[6], and Borge[7]; and three papers have recently been published in the 'Victorian Naturalist' by Mr. Hardy[8], enumerating a variety of Algæ from parts of Southern Victoria. In the latter papers, at Mr. Hardy's request, I described the new forms, and descriptions of some of them have also appeared in the 'Journal of Botany'[9].

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[1] O. Nordstedt, "Fresh-water Algæ collected by Dr. S. Berggren in New Zealand and Australia." Kongl. Sv. Vet.-Akad. Handl. xxii. no. 8 (1888).

[2] W. J. Spencer, "Notes on Fresh-water Algæ." Trans. and Proc. N. Zeal. Instit. xv. (1883).

[3] W. M. Maskell, "On the New Zealand Desmidieæ." Trans. and Proc. N. Zeal. Instit. xv. (1883); also xviii. (1885). To these must be added Maskell's later paper, "Further Notes on the Desmidieæ of New Zealand," *l. c.* xxi. (1889).

[4] M. Raciborski, "Desmidyja zebrane przez Dr. E. Ciastonia etc." Rozpraw Wydz. matem.-przyr. Akad. Umiej. Krakow. xxii. (1892).

[5] M. Moebius, "Australische Süsswasseralgen." Flora, Heft 3 (1892).

[6] W. Schmidle, "Süsswasseralgen aus Australien." Flora, Bd. 82, Heft 3 (1896).

[7] O. Borge, "Australische Süsswasserchlorophyceen." Bih. till K. Sv. Vet.-Akad. Handl. xxii. no. 9 (1896). Most of this work and some of the preceding works have been partly republished in F. M. Bailey's 'Contributions to the Queensland Flora,' xi. (1895), xv. (1898); unfortunately the defective figures of Cooke and of Wolle have been largely copied in these publications.

[8] A. D. Hardy, "The Fresh-water Algæ of Victoria," Victorian Naturalist, xxi. (1904); xxii. (1905); xxiii. (1906).

[9] G. S. West, "Desmids from Victoria." Journ. Bot., Sept. 1905.

The latest contribution to our knowledge of Australian Algæ is a paper by Playfair on Desmids from New South Wales *. This paper is unfortunately too reminiscent of W. B. Turner's "Fresh-water Algæ of East India" †. It affords a marked contrast to the careful work of Nordstedt, exhibiting a want of experience of the family dealt with ‡. Especially is this the case in the suggestions for grouping well-marked types under one species and in the founding of other species on the most trivial characters. There is likewise an inexactitude in the figures which is but too common among the students of this group of Algæ. Judging by his continual references to "immature forms," Mr. Playfair seems to have rather curious ideas on the growth of Desmids. He appears to imagine that a Desmid may change its form, or develop spines or warts, at any time during its existence, losing sight of the fact that, unless dealing with monstrosities, *at least one semicell of any Desmid must be mature.* Cell-division, except under abnormal circumstances, does not take place until the two halves of a Desmid are equally developed, the newer half having arrived at maturity. Consequently, *in any Desmid in which the two semicells are exactly alike, growth has ceased, and that individual is mature* §. Further alteration of form, excluding the possibility of changes caused by the attacks of parasites, does not take place after the completion of the development of the new half, and spines once formed cannot become bifid or trifid, or in some other way change their nature, as Mr. Playfair appears to imagine. Neither do monstrosities appear to be particularly common in Australia. I have examined large numbers of Australian Desmids, and cell-division amongst this family appears to take place in Australia much as it does elsewhere, the new semicells arriving at maturity with but slight variation from the old ones.

The works which have just been cited, together with the present investigation, although dealing with very limited and somewhat remote parts of the Australian continent, yet enable one to form a general idea of the Alga-flora of Eastern Australia. They are also sufficient to show that among the more cosmopolitan forms there are a number of types peculiar to Australia and New Zealand. These are specially considered in a succeeding chapter.

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* G. J. Playfair, "Some new and little-known Desmids found in New South Wales." Proc. Linn. Soc. N. S. Wales, xxxii. part 1 (1907), pp. 160-200, t. 2-5.

† W. B. Turner in Kongl. Sv. Vet.-Akad. Handl. xxv. no. 5 (1893).

‡ Mr. Playfair describes under the name of "*Closterium Cancer*, sp. n." either a species of the Protococcaceous genus *Reinschiella* or a resting-cyst of one of the Peridiniales; his description and figure are insufficient to determine the point. Under the name of "*Closterium naviculoideum*, sp. n." he appears to have described one of the common attenuated Diatoms of the genus *Nitzschia*, presumably *Nitzschia acicularis*. He also states that another species of *Closterium* ("*C. calamus*, sp. n.") possesses parietal chloroplasts, whereas his figure clearly shows the usual axile ridged chloroplasts of *Closterium* with a central row of pyrenoids.

§ The only exceptions to this are those few species of *Closterium* and *Penium* which develop a "girdle-band." This is a cylindrical piece of cell-wall intercalated between the new and the old half-cells, and resulting from a growth to maturity subsequent to the completion of cell-division.

The present chapter deals only with those species observed in Mr. Hardy's collections which are deemed worthy of special mention, either because they have not previously been described, or because the Australian specimens have furnished new facts concerning them.

It is difficult to say which of the following 68 species should be regarded as the most interesting, but one could with justice include in such a selection *Ulothrix idiospora*, *Radiofilum conjunctivum*, *Debarya Hardyi*, *Micrasterias Hardyi*, *Staurastrum victoriense*, *Lagerheimia splendens*, *Rhizosolenia morsa*, *Gyrosigma elongatum*, and *Peridinium Volzii* var. *australe*.

Class **CHLOROPHYCEÆ.**

Order OEDOGONIALES.

Family **OEDOGONIACEÆ.**

Genus OEDOGONIUM, *Link*.

1. OEDOGONIUM SUECICUM, *Wittr. in Botan. Notiser* (1872) p. 5 ; *Hirn, in Acta Soc. Scient. Fennicæ*, xxvii. (1900) p. 82, t. 2. fig. 15.

Forma AUSTRALIS. (Text-fig. 6, E.)

Forma cellulis vegetativis paullo crassioribus ; echinis robustioribus et sparsioribus.

Crass. cell. veget. .... 14–16 μ ; altit. 4–5-plo major ;
„ oogon. .... 40–41 μ ; „ 40–41 μ ;
„ oospor. (sine echin.) 31–33 μ ; „ 31–33 μ.
Long. echin. 2·5–3 μ.

Hab. Yan Yean Reservoir, at the weedy margin (Nov. 1905).

2. OEDOGONIUM OBLONGUM, *Wittr. in Botan. Notiser* (1872) p. 2 ; *Hirn, l. c.* p. 185, t. 29. fig. 181.

Crass. cell. veget. ...... 6·5–7·5 μ ; altit. 4–8-plo major ;
„ oogon............ 20–24 μ ; „ 46–60 μ ;
„ oospor. .... 19–22 μ ; „ 34–36 μ.

Hab. Yan Yean Reservoir, among the weeds (in fruiting condition Nov. and Dec. 1905).

3. OEDOGONIUM MONILE, *Berk. & Harv. in Hook. f. Flora Tasmaniæ*, ii. (1860) p. 342, t. 196. fig. B ; *Hirn, l. c.* p. 229, t. 38 et 39. fig. 235.

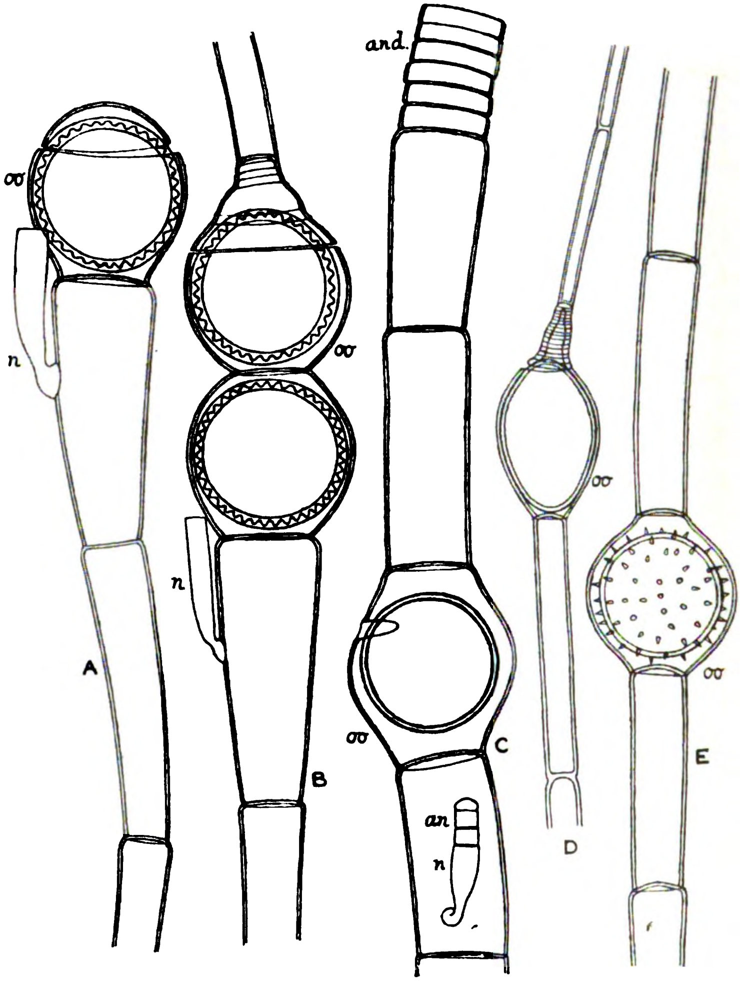
Forma VICTORIENSE. (Text-fig. 6, A & B.)

Forma paullo major ; nannandribus elongatis et angustioribus, in cellulis suffultoriis sedentibus.

Crass. cell. veget.	12–44 μ;	altit.	5–7-plo major;
,, ,, suffult. ...	27–28 μ;	,,	2½–3-plo major;
,, oogon............	42–45 μ;	,,	42–52 μ;
,, oospor.	40–42 μ;	,,	40–42 μ;
,, stip. nannandr..	6·5–8 μ;	,,	38–44 μ.

Hab. Yan Yean Reservoir, among the weeds (in fruiting condition in Dec. 1905).

Fig. 6.



A and B. *Oedogonium monile*, Berk. & Harv., forma *victoriense*, ×500; C. *O. victoriense*, G. S. West, ×470; D. *O. pisanum*, Wittr., ×520; E. *O. suecicum*, Wittr., forma *australe*, 500. *oo*, oogonia; *n*, nannandrium; *an*, antheridium; *and*, androsporangium.

The oogonia of the Australian form were solitary or binate, and not infrequently a single oogonium terminated the filament. Not only is typical *O. monile* known from Victoria, but three distinct forms of it are known to occur in Australia. The present form is distinguished from them all by the narrower and more elongated dwarf-males. It should be compared with forms of *O. Borisianum*, (Le Cl.) Wittr.

4. OEDOGONIUM VICTORIENSE, *G. S. West in Victorian Naturalist*, xxiii. (1906) p. 22.

Oe. dioicum, nannandrium, gynandrosporum ; oogoniis singulis, ellipsoideo-globosis vel ellipsoideo-doliiformibus, poro superiore apertis ; oosporis exacte globosis, oogonia non complentibus, episporio glabro ; androsporangiis 5–6-cellularibus ; nannandria in cellulis suffultis sita, stipite curvato, antheridiis internis bicellularibus ; cellulis suffultis levissime dilatatis. (Text-fig. 6, C.)

Crass. cell. veget.	25–29 μ ;	altit.	2–3-plo major ;
,, oogon.	49 μ ;	,,	57 μ ;
,, oospor.	39 μ ;	,,	39 μ ;
,, androsporang....	25–26 μ ;	,,	4·2–8 μ ;
,, cell. antherid....	7·5 μ ;	,,	4·8 μ.

Hab. In a shallow pool in the Yan Yean drainage area (Oct. 1905).

This species is perhaps nearest to *O. crassiusculum*, Wittr., but differs in its solitary oogonia and exactly globose oospores, the latter by no means filling up the former. The nannandria are also much more curved and the antheridia two-celled. From *O. macrandrium*, Wittr., it is distinguished by the greater thickness of its vegetative cells, by the solitary oogonia with a superior pore, and by the relatively smaller size of the oospore. It is also gynandrosporous, whereas *O. macrandrium* is not. *O. victoriense* should also be compared with *O. cataractum*, Wolle.

Order CHÆTOPHORALES.

Family **ULOTRICHACEÆ.**

Genus ULOTHRIX, *Kütz.*

5. ULOTHRIX IDIOSPORA, sp. n. (Pl. **2.** figs. 12–14.)

U. in cæspitibus parvis inter alias algas aquaticas reperta ; filis vegetativis subflexuosis, cellulis diametro ¾–2¼-plo longioribus ; chromatophora parva parietali leviter lobata, cum pyrenoide singulo conspicuo ; sporis solitariis vel seriatim dispositis, ellipsoideis, doliformibus, vel elongatis et subcylindricis, diametro cell. veget. majoribus, membrana crassa, grosse et irregulariter scrobiculata.

Crass. cell. veget. 8–10 μ; long. spor. 18–36 μ; lat. spor. 10–13 μ.

Hab. Yan Yean Reservoir: sparingly among *Mougeotia victoriensis* and several species of *Oedogonium* at the weedy margins (Nov. 1905). Also more abundantly, mixed with *Tribonema bombycina*, in small, shallow pools in Honeysuckle Flat (Sept. 1907).

This species of *Ulothrix* is at once characterized by the peculiar nature of its spores. They arise, either singly or in chains of upwards of 20, from the ordinary vegetative cells. During the formation of a spore the vegetative cell increases to about twice its volume and becomes ellipsoid or doliform. The cell-wall increases much in thickness and possesses in the ripe spore numerous coarse scrobiculations. It is the scrobiculated character of the wall of these spores which distinguishes *U. idiospora* from all other described species of *Ulothrix*. The spores are resting-spores (hypnospores) and come under the heading of "akinetes," as they arise by the further growth of the original mother-cell, and not by the formation of an entirely new cell-wall within that of the mother-cell.

In the thickness of its vegetative filaments *U. idiospora* is very similar to *U. tenerrima*, Kütz. (*vide* Hazen in Bull. Torr. Bot. Club, xi. (1902) p. 151, t. 21. figs. 3–4), but the cells are generally proportionately longer. The akinetes of *U. tenerrima*, and indeed of all the allied species, are shorter and more angular than those of *U. idiospora*, with thinner, perfectly smooth walls.

Spores were rarely observed in the filaments from the weedy margins of the reservoir, but from the shallow pools in Honeysuckle Flat most of the filaments were in a state of spore-formation. Mr. Hardy writes that the water of these pools was warmed by the sun almost to a tepid condition, as they were only about four feet across and but a few inches deep, having been left by the receding of the water of the reservoir. Spore-formation seems thus to have been produced by the increase in temperature of the water and the incipient drying-up of the pools. The spores would remain in the mud on the pools becoming quite dry, germination taking place on the re-flooding of these hollows, which takes place when the water of the reservoir is very high.

Genus RADIOFILUM, *Schmidle.*

6. RADIOFILUM CONJUNCTIVUM, *Schmidle, in Flora*, Bd. 78 (1894), p. 47, t. 7. figs. 4–5; *Chodat*, "*Algues Vertes de la Suisse*," *Beitr. Kryptogamenfl. Schweiz*, 1902, p. 271.—R. apiculatum, *W. & G. S. West, in Journ. Bot.* xxxiii. (1895) p. 52; *Bohlin, in Bih. till K. Sv. Vet.-Akad. Handl.* xxiii. (1897) p. 10, t. 1. figs. 6–8.

Lat. cell. 4·5–6 μ; long. cell. 5–8 μ. (Pl. **6**. figs. 1–3.)

Hab. Among weeds, Honeysuckle Flat, and in small pools, Ottelia Creek (Sept. 3, 1907).

This interesting member of the Ulotrichaceæ has been previously found in Germany, the United States, and Paraguay. The Australian forms agree with those described as *Radiofilum apiculatum* in the presence of a slight apiculus at each side of the cell, but the cells themselves are proportionately longer. *R. apiculatum* must now be regarded as identical with *R. conjunctivum*, since Schmidle has re-examined his specimens of the latter and found that he omitted some of the most salient characters from his original description—characters upon which the species *R. apiculatum* was founded (*vide* Schmidle, in Botan. Zeitschr. (1900) no 12).

The wall of each individual cell is composed of two halves, and cell-division appears to take place much as it does in some of the simpler types of Desmids, such as *Penium*, by the interpolation of two new half-cells between the old ones. The line of junction of the old and new halves of the wall is distinctly visible in most specimens, and is particularly obvious at the marginal apiculations, the latter owing their prominence to the projecting suture at this region. Each fully-grown half is helmet-shaped, but in its earliest stages the young half is much flattened. The chloroplasts are parietal and cup-shaped, occupying about two-thirds of the interior of the cell-wall. They are disposed very largely back to back in pairs of adjacent cells. The connections between the cells are not mucilaginous, but are caused by polar thickenings of the cell-wall. In the apical cell of a filament the terminal, free half of the cell is hemispherical.

One filament was observed which possessed a lateral branch (Pl. 6. fig. 3), the basal cell of the branch being attached by a forked polar connection to two cells of the main filament. This branch most likely arose as a result of rapid cell-division, the middle cell of three sliding out laterally and developing a connection with each of the other two.

Möbius has described (in Abhandl. d. Senckenb. naturf. Ges. xviii. (1894) p. 320, t. 1. figs. 22–25) from Queensland an Alga which he placed as a variety of *Hormospora transversalis*, Bréb.; but it appears probable from his description of the cell-division, that the plants he observed should be relegated to the genus *Radiofilum*. In the two known species of the latter genus—*R. conjunctivum* (including *R. apiculatum*) and *R. flavescens*—no longitudinal division of the cells has been observed such as Möbius describes as occurring in his Queensland plants. Möbius considers that the genus *Hormospora* should have a place in the Tetrasporaceæ in proximity to *Palmodactylon*; but, so far as I can judge from a wide knowledge of all these genera, there is no doubt whatever that both *Hormospora* and *Radiofilum* are feebly developed members of the Ulotrichaceæ.

Order CONJUGATÆ.

Family **ZYGNEMACEÆ.**

Genus MOUGEOTIA, *Ag.*

7. Mougeotia subcrassa, sp. n. (Pl. 2. figs. 4–5.)

M. crassa, cellulis vegetativis diametro 6–6½-plo longioribus, chromatophora magna et crassa cum pyrenoidibus subirregulariter dispositis numerosis (15–24); sporis ubi conjugatione scalariformi productis, globosis et subparvis, diametro cellularum veget. æqualibus; membrana sporæ glabra et indistincte lamellosa; cellulis conjugationibus fere rectis vel levissime curvatis.

Crass. cell. veg. 41·5–43 μ; diam. spor. 40–41 μ.

Hab. Yan Yean Reservoir; among the weeds (Oct. and Nov. 1905).

The best conjugated specimens of this species were observed in November. It is remarkable for the relatively small size of the spores as compared with the diameter of the vegetative cells, a character which distinguishes it from *M. scalaris*, Hass., and *M. crassa*, Wolle. It is also distinguished from the former by the much greater thickness of its vegetative cells and by the larger chloroplasts with more numerous pyrenoids; and from the latter by its slightly longer and thinner vegetative cells.

The spore-wall is thicker next the sterile cells than at its exposed parts, as in these regions the partition-walls which cut off the fertile cell (spore) from the two sterile cells are fused with the more newly-formed wall of the spore. It was this manifest partition of the conjugated structure into fertile and sterile cells, *before the formation of any actual spore-walls*, which induced Wittrock to regard this part of the life-history of *Mougeotia* as a rudimentary sporophyte.

8. Mougeotia recurva, (*Hass.*) *De Toni.*—Mesocarpus recurvus, *Hass. Brit. Freshw. Alg.* 1845, t. 43. fig. 2.

Crass. cell. veget. 12–14 μ; diam. spor. 25–28 μ.

Hab. Yan Yean Reservoir; among weeds (Nov. 1905).

I am in considerable doubt about this determination. Only a few specimens were observed, and they differed in the proportionately longer vegetative cells and in the straightness of the conjugating cells. The plants observed were probably abnormal states, as *some of the filaments had produced both globular and cylindrical aplanospores*, the former (diam. 24 μ) at the outer angles of geniculate cells (*vide* Wittrock, in Bih. till Sv. Vet.-Akad. Handl. i. (1872) t. 2. figs. 7, 8), and the latter (long. 34 μ; lat. 14 μ) in the middle of straight cells.

9. Mougeotia victoriensis, sp. n. (Pl. 2. fig. 1.)

M. subparva, cellulis vegetativis diametro 9½–14-plo longioribus, chromatophora elongata cum pyrenoidibus 2–7 (plerumque 5–6) in serie singula subirregulariter ordinatis; cellulis conjugatis elegante genuflexis; sporis globosis; intra cellulas steriles parte inclusis, membrana glabra; circa sporam unamquemque et partes propinquas cellulæ sterilium cum tegumento mucoso amplo sphærico.

Crass. cell. veget. 11·5–12 μ; diam. spor. 21–24 μ; diam. integ. mucos. 60–63 μ.

Hab. Yan Yean Reservoir; at the weedy margins (Nov. 1905).

M. victoriensis is undoubtedly nearest to *M. parvula*, Hass., but is distinguished by its slightly thicker vegetative cells, which are also somewhat more elongate, and by the large gelatinous envelope surrounding the spores. One other species of this genus is known with a wide gelatinous coat enveloping the spores, namely, *M. gelatinosa*, Wittr. (in Wittr. & Nordst. Alg. Exsic. (1889) no. 957, fasc. 21, pp. 26, 27 cum fig.). This species, which I have examined from both England and Scotland, differs much from the Australian plant in the thickness of its vegetative cells and in the form of its spores. Moreover, the mucous coat of the spore is usually interpolated between the spore-wall and the adjacent parts of the conjugating-tube, whereas in *M. victoriensis* the mucous coat envelops not only the spore but also the adjacent parts of the gametangia (the sterile cells of Wittrock). The conjugating-tube of *M. victoriensis* is relatively much wider than that of *M. parvula* or *M. gelatinosa*, and the spores are partially immersed in the gametangia.

The gelatinous coat surrounding the spore of *M. victoriensis* is almost three times the diameter of the spore itself, and is commonly encrusted with minute particles of mineral and organic detritus.

Genus DEBARYA, *Wittr.*

10. Debarya Hardyi, sp. n. (Pl. 2. figs. 6–11.)

D. inter alias Conjugatas intermixta; cellulis vegetativis 9–16-plo longioribus, pyrenoidibus 2–4 in seriem unicam dispositis in chromatophoro unoquoque; zygosporis ubi conjugatione scalariformi productis, quadratis, lateribus rectis vel levissime concavis interdum incrassatis, angulis incrassatis et cornutis, cornubus cylindricis et solidis e semigamitangiis reliquis formatis; membrana cornu delicatissime lamellosa.

Crass. cell. veget. 6·4–7·5 μ; diam. zygosp. (sine corn.) 22·5–27 μ.

Hab. Found sparingly amonst *Zygnema spontaneum*, *Gonatozygon monotænium*, etc., at the weedy margins of the Yan Yean Reservoir (Jan. 1906).

This is the narrowest described species of the genus *Debarya*, and in outward appearance presents many resemblances to *Mougeotia gracillima*.

The conjugating-tube is formed in the normal way and becomes very wide. During the fusion of the gametes the gametangia undergo a marked change. The terminal transverse walls increase greatly in thickness by the deposition of layer after layer of cellulose, and a slight thickening of the side walls also occurs. As this thickening goes on the cavity of the gametangium is gradually reduced and a hemispherical, or sometimes a bluntly conical mound of cellulose projects into the emptying gametangium. The metamorphosis of the gametangium, which might almost be described as a "solidification," keeps pace with the receding of the gametes, and when the latter have completely coalesced in the wide conjugating-tube, the proximal ends of the four solid processes project as four rounded buttons into the cavity of the zygospore. The mature zygospore possesses four cylindrical truncate horns, each of which has arisen without external change of form from one half of a gametangium, the latter having become *solid* by the deposition of an internal thickening of cellulose.

I have pointed out on previous occasions the curious change which is undergone by the gametangia of species of *Debarya* during conjugation*. In *D. desmidioides* there are four solid processes to each zygospore formed in a similar way to those of *D. Hardyi*. In *D. africana* the thickening is considerable, and laid down evenly except for the terminal pits, but the gametangia do not become solid.

The gradual acquirement of solidity by the erstwhile thin-walled gametangia of *D. Hardyi* is well shown in figs. 7–9, Pl. 2.

Genus ZYGNEMA, *Ag.*

11. Zygnema spontaneum, *Nordst. Alg. aq. dulc. et Char. Sandvic.* 1878, p. 17, t. 1. figs. 23–24; *W. & G. S. West, in Journ. Bot.* 1897, p. 40; *in Ann. Roy. Bot. Gardens, Calcutta*, vi. (1907) p. 184.—Z. Heydrichi, *Schmidle, in Flora*, lxxxiv. (1897) p. 169, t. 5. figs. 5–7, 10, 11.

Crass. cell. veget. 15·5–17 μ; diam. zygosp. 29–34 μ; diam. aplanospor. 20 μ. (Pl. 2. figs. 2–3.)

Hab. Yan Yean Reservoir, at the weedy margins (Nov. and Dec. 1905; Jan. 1906).

In size and proportions, and also in the aplanospores, the Australian examples agreed almost exactly with those described by Nordstedt from the Sandwich Is., but the zygospores exhibited a considerable degree of variation in form and position. The zygospores previously observed from W. Africa and from Burma were entirely contained in the female gametangium, which was slightly swollen to accommodate the spore. In the Australian specimens the zygospores were of relatively greater diameter, and that part of the female gametangium in which the spore was lodged was of necessity much inflated, although the inflation was restricted to the exact place of lodgment. The conjugating-tubes were generally very wide and the zygospore projected into them, in some cases almost into the male gametangium. A few specimens were observed in which the zygospore was situated in the conjugating-tube midway between the two gametangia, and these examples afford further evidence of the identity of *Zygnema Heydrichi*, Schmidle, with *Z. spontaneum*. Schmidle's specimens were from near Sydney, and the conjugation was lateral, the zygospores being formed in the conjugating-tube. The Victorian specimens exhibited no lateral conjugation, but aplanospores were formed in filaments which in other parts were conjugating in a scalariform manner.

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* W. & G. S. West in Journ. Bot., March 1903, p. 8; G. S. West, Treatise Brit. Freshw. Alg. 1904, p. 127; in Journ. Linn. Soc., Bot. xxxviii. (1907) p. 104.

Family **DESMIDIACEÆ**.

Genus PENIUM, *Bréb.*

12. Penium margaritaceum, (*Ehrenb.*) *Bréb. in Ralfs, Brit. Desm.* (1848) p. 149, t. 25. figs. 1 *a–c* ; *W. & G. S. West, Brit. Desm.* i. (1904) p. 83, t. 8. figs. 32–35.

Var. irregulare, *W. & G. S. West, in Trans. Bot. Soc. Edin.* xxiii. (1905) p. 14, t. 1. fig. 23.

Long. 142 μ ; lat. max. 30 μ ; lat. apic. circ. 20 μ.

Hab. Wallaby Creek Weir, at the outlet (July 1907).

Genus PLEUROTÆNIUM, *Näg.*

13. Pleurotænium mamillatum, *G. S. West, in Victorian Naturalist*, xxii. (1905) p. 70 ; *in Journ. Bot.* xliii. (1905) p. 252.

P. submediocre, modice elongatum, cellulis diametro 14–17-plo longioribus ; semicellulæ subcylindricæ, leviter et gradatim attenuatæ e medio apicem versus, inflatione subprominenti ad basin et marginibus 10–11-undulatis, undulis gradatim minoribus apicem versus; apicibus convexo-truncatis, verrucis magnis conico-mamillatis (subunguiculatis) subdivergentibus 6–7 (visis 4) instructis ; membrana subsparse punctata.

Long. 372–495 μ ; lat. bas. semicell. 28–32 μ ; lat. med. semicell. 27–31 μ ; lat. apic. semicell. sine verruc. 17–29 μ, cum verruc. 21–25 μ. (Pl. **3.** figs. 1–2.)

Hab. Yan Yean Reservoir, in the plankton (Feb.–Apr. 1905) and at the weedy margins (July 1905), but more frequent in the plankton.

This species is readily distinguished by the large size and elongated character of the apical warts. The latter are mamillate in appearance, and possess a slight outward and upward curvature, which in some individuals is intensified until the warts become almost unguiculate. The total number of apical warts on any individual semicell may be six or seven. The margins of the semicells are undulate from base to apex, the undulations, which are 10 or 11 in number, becoming gradually less distinct towards the apex. The lower half of each semicell is approximately cylindrical, but the upper half is distinctly attenuated. Specimens of *P. mamillatum* are frequently found attached by their apices in pairs, separation of the cells not following immediately after division.

14. PLEUROTÆNIUM OVATUM, *Nordst. in Öfvers. af K. Vet.-Akad. Förh.* no. 3 (1877), p. 18.—Docidium ovatum, *Nordst.*, 1870.

Var. TUMIDUM, *Maskell, in Trans. N. Zeal. Instit.* xxi. (1889) p. 29, t. 6. fig. 54.—? Docidium rotundatum, *W. B. Turner, in K. Sv. Vet.-Akad. Handl.* xxv. no. 5 (1893), p. 37, t. 7. fig. 2 *a*.

Forma marginibus lateralibus superioribus semicellularum leviter concavis (=*Docidium pyriforme*, W. B. Turner, *l. c.* t. 7. fig. 3); tuberculis apicalibus magnitudinis variabilis 6–9; membrana laterum inferiorum incrassata.

Long. 241–262 μ; lat. max. 94–100 μ; lat. apic. 35–40 μ.

Hab. Yan Yean Reservoir, at the weedy margins (Nov. and Dec. 1905).

The form seen differs from that described by Maskell from New Zealand in the retuseness of the upper parts of the lateral margins of the semicells. Almost exactly the same form was observed from Cheltenham, Victoria: long. 240–255 μ; lat. max. 89–98 μ; lat. apic. 29·5–32·5 μ. *From the latter locality one zygospore was found* (consult Hardy in Victorian Naturalist, xxiii. (1906) p. 21). It was subglobose, externally smooth, and the wall consisted of three distinct coats, each of which was lamellose. The middle and inner coats had shrunk away from the outer one, especially at one side, and the middle coat was papillate, the papillæ being sparsely scattered, blunt, and 2–2·7 μ in length. Diam. zygosp. 96–108 μ. (Pl. 6. fig. 9.) For a zygospore to possess a *papillate* middle coat is a most unusual occurrence.

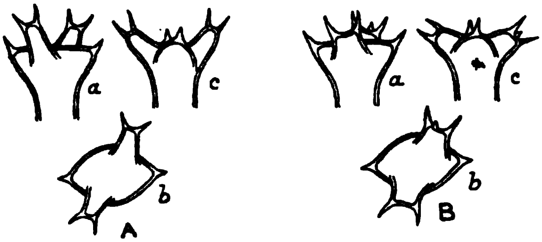
Genus TRIPLOCERAS, *Bail.*

15. TRIPLOCERAS GRACILE, *Bail. in Smithson. Contrib.* ii. (1851) p. 38, t. 1. fig. 10 [figure poor]; *Wittr. in Nov. Act. reg. Soc. Sci. Upsala*, vii. (1869) p. 21, t. 1. fig. 10 [figures not good].—T. gracile, *forma, W. & G. S. West, in Trans. Linn. Soc.* ser. 2, *Bot.* v. (1896) p. 236, t. 13. figs. 9–13. [*Etiam inclus.* T. gracile *forma* elongata, T. gracile *f.* gracillima, T. gracile *f.* quadriloba, *et* T. gracile *subsp.* bilobatum, *W. B. Turner, in K. Sv. Vet.-Akad. Handl.* xxv. no. 5 (1893), pp. 25, 26, t. 2. figs. 1–4.]

Turner's statement (*l. c.* p. 26) that "*Triploceras gracile* is perhaps the most polymorphic species known" is singularly near the mark, but whatever virtue the statement possessed he at once destroyed by naming four forms of this most variable species on characters which are not only trivial, but which appear to be founded mostly on inaccuracies of observation and drawing. *Triploceras gracile* certainly exhibits the widest range of variation of any known Desmid, and confusion has always existed as to which form, if any, should be regarded as the type-form.

The form described and figured as "*T. gracile*, forma" in the Trans. Linn. Soc. ser. 2, Bot. v. (1896) p. 236, t. 13. figs. 9–13, is the generally-distributed form in the United States, occurring from Maine to Florida. Bailey's original specimens were also collected in the eastern parts of the United States, and it is therefore highly probable that they were in no way different from this form. In fact, a close scrutiny of Bailey's figure, although a wretched drawing, confirms this opinion. Moreover, precisely the same form occurs in Central America, India, Ceylon, and Queensland. Taking all these facts into consideration, there is every reason for regarding this form as the type-form of the species *. The characters of importance of this form, which I shall henceforth consider as the type-form, are the whorls of acuminate verrucæ and the peculiar apical lobulation. The apex of each semicell is slightly flattened and is furnished with two divergent processes, somewhat obliquely disposed and bispinate (rarely trispinate) at their extremities. Alternating with these processes are two shorter apical lobes each of which terminates in an upwardly-curved spine. These more rounded lobes sometimes possess a subsidiary papilla (or even a spine) below the terminal one, and the relative proportions of the two spinate processes vary much. These variations, which are shown in the accompanying figures (text-fig. 7, A & B), in no way affect the distinctiveness of the apical characters. The number of whorls of acuminate verrucæ on a semicell is very variable (9–16), and the acuminate apices of these warts often graduate into shortly spinate apices. These are the limits of variation I have noticed in the type-form. Most of

Fig. 7.



Apices of two semicells of the type-form of *Triploceras gracile*, Bail. In B the obliquely disposed processes are shorter and broader than in A. *a*, front view; *b*, apex seen from the vertical view; *c*, side view. All × 500.

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* Dr. O. Borge has also regarded this form as the type. *Cf.* Borge, in Bih. till K. Sv. Vet.-Akad. Handl. xxii. no. 9 (1896), p. 28, t. 4. fig. 57.

the misconceptions in the past have resulted from the failure to realise the differences which the apex presents when viewed from various positions.

The second well-established form of *Triploceras gracile* is var. *bidentatum*, Nordst., in which the warts of the rings are bidentate. This well-know variety is frequent in Brazil, and has been found in India and New Zealand.

The three following varieties are less well known; they all occurred in the Yan Yean area of Victoria :—

Var. ACULEATUM, *Nordst.* [T. gracile, *subsp.* aculeatum, *Nordst. in Kongl. Sv. Vet.-Akad. Handl.* xxii. no. 8 (1888), p. 64, t. 7. figs. 13, 14.]

Forma aculeis verticillorum plus elongatis et patentibus; verticillis 8–9 i semicellula unaquaque.

Long. 238–260 μ; lat. bas. semicell. (sine acul.) 22 μ, cum acul. 36–38 μ; lat. apic. c. spin. 28–31 μ. (Pl. **3**. figs. 6–7.)

Hab. Yan Yean Reservoir, at the weedy margins (Mar. 1905); also i pools in Ottelia Creek (Sept. 1907).

The verticillate warts of the semicells were aculeate, but the aculei wer more spreading than in Nordstedt's New Zealand specimens. Playfair ha described a forma *australica* of this variety from New South Wales, but the Victorian forms all possessed more spreading spines.

Var. ROBUSTUM, var. n. (Pl. **3**. figs. 4–5.)

Var. major, elongatum et robustior, verticillis 16–18 in semicellula unaquaque, verrucis verticillorum mamillatis et spinatis; processibus duobus ad apicem semicellularum elongatis et robustis, 2–4-aculeatis.

Long. 560–584 μ; lat. bas. semicell. c. spin. 43–45 μ; lat. max. apic. c. spin. 60 μ.

Hab. Yan Yean Reservoir, at the weedy margins (Jan. 1906); also i pools in Ottelia Creek and in Honeysuckle Flat (Sept. 1907).

This large and handsome variety stands near to that described from New Zealand by Nordstedt as "var. *bidentatum* f. *intermedia*" (*cf.* Nordst. *l. c.* p. 64, t. 7. fig. 17).

Var. DENTICULATUM, nob. [=? T. denticulatum, *Playfair, in Proc. Linn. Soc. New South Wales*, xxxii. part. i. (1907) p. 164, t. 2. fig. 11.]

Var. verrucis verticillorum plerumque bispinatis (in parte apicali nonnunquam unispinatis), apice semicellulæ ut in var. *aculeato* verisimiliter.

Long. 388–464 μ; lat. bas. semicell. c. spin. 21·5–26 μ; lat. apic. semicell. c. spin. 19–27 μ. (Pl. **3**. figs. 8–10.)

Hab. Yan Yean Reservoir, at the weedy margins (Mar. 1905).

It does not seem possible to separate the form observed from Victoria from Playfair's *T. denticulatum*, as the double rings of spines are characteristic of each form. In the Victorian specimens, however, some of the

upper rings (from 2–9) possess only a single series of spines as in the more typical forms of *Triploceras gracile.* Such a form as that figured on Pl. **3.** fig. 8 is clearly but a variety of *T. gracile,* notwithstanding the absolute agreement of the basal half of the semicell with *T. denticulatum.*

Although the three Australian forms from the Yan Yean area differ very considerably in the character of the verticillate warts, the apices all conform to one pattern, which on careful comparison is not so very different from that found in the type-form. No specimen was observed with three apical processes such as are figured by Playfair for *T. denticulatum.*

Genus EUASTRUM, *Ehrenb.*

16. Euastrum Turneri, *West, in Journ. Linn. Soc., Bot.* xxix. (1892) p. 141, t. 20. fig. 18. ("*Eu.* sp. ad *E. denticulatum* accedens," Nordst. 1888.)

Forma minor.

Forma minor, granulis paucioribus.

Long. 21 μ ; lat. 15·5 μ ; lat. isthm. 5 μ.

Hab. Yan Yean Reservoir, at the weedy margins (common from Nov. 1905 to Jan. 1906).

Genus MICRASTERIAS, *Ag.*

17. Micrasterias Hardyi, *G. S. West, in Victorian Naturalist,* xxii. (1905) p. 71, fig. 1 ; *Journ. Bot.* xliii. (1905) p. 253.

M. submagna, paullo longior quam lata, profundissime constricta, sinu valde aperto acutangulo ad extremum angustissimo semicellulæ trilobæ ; lobo polari magno et leviter exerto, parte inferiore angusta cum marginibus subparallelis et cum serie denticulorum circ. 7 intra marginem lateralem unumquemque, apicibus cum verrucis emarginatis binis et processibus minutis brevibus emarginatis duobus asymmetrice dispositis, angulis superioribus in processus longos denticulatos gradatim attenuatos sursum divergentes productis; lobis lateralibus profundissime bilobulatis, lobulis magnis elongatis denticulatis divergentibus et gradatim attenuatis ; apicibus lobulorum et processuum lobi polaris 4-dentatis ; cum serie denticulorum intra lobulos laterales et processus lobi polaris ; a vertice visæ anguste fusiformes, in parte mediana subrhomboideæ, apices versus gradatim attenuatæ in processus denticulatos quadridentatos productæ, marginibus lateralibus denticulatis.

Long. 198–235 μ; lat. 161–219 μ ; lat. isthm. 16–18 μ ; crass. 28 μ. (Pl. **5.** figs. 1–2.)

Hab. Yan Yean Reservoir, abundant in the plankton for the greater part of the year.

This handsome species belongs to that section of the genus inclu *Micrasterias americana* and *M. mahabuleshwarensis*, in which the polar lo furnished with accessory processes. It is at once distinguished from species by the great length and divergence of the lateral lobules and processes of the polar lobe. Accompanying this is a great reduction o two accessory asymmetrical processes of the polar lobe, which are minute, with smooth margins and bidenticulate apices.

M. Hardyi is one of the most conspicuous constituents of the plankt the Yan Yean Reservoir, and for thirteen months it was never absent the tow-nettings. It exhibits little variation, and only one abnormal cimen was observed among many thousands. In this individual the la lobes of one semicell were undivided, resembling the lateral lobes of *M. tr* but much more attenuated. Large numbers of specimens were observ various stages of cell-division, and in the young semicells the lateral are always entire and bluntly rounded. The four teeth at the atten apices of the lobes are not easily all observed, but they were present in specimen examined.

18. MICRASTERIAS THOMASIANA, *Archer, in Journ. Micr. Soc.* new s (1862) p. 239, t. 12. figs. 1–5 ; *W. & G. S. West, Monogr. Brit. Des* (1905) p. 110, t. 51. figs. 3–6.

Var. PULCHERRIMA, var. n. (Pl. **4**. fig. 1.)

Semicellulæ cum processu brevi bidentato extrorsum curvato intra lobuli lateralis uniuscujusque ; dente magno infra incisionem lobi lat superioris ; processibus lateralibus magnis duobus ad basin semicellul dente magno superiore instructis.

Long. 219 μ ; lat. 197 μ ; lat. isthm. 30 μ ; crass. max. 65 μ.

Hab. Toorourong Reservoir, in the plankton (July 1907).

This beautiful Desmid was not uncommon in the tow-nettings obtain boat from the Toorourong Reservoir, and was one of the only two De present in the collections. It differs in a conspicuous manner from all described forms of *M. Thomasiana* in the sixteen short, bidentate pro disposed one within each lateral lobule. The teeth within the divisions lateral lobes, 32 in the front view of a single cell, are present exactly the type, but there is an additional tooth close to the base of each su lateral lobe, and there are some extra ones near the margin of each lobe. The larger, outwardly curved, lateral processes at the base of semicell also possess an extra dorsal tooth of large size.

M. Thomasiana is known from the western parts of Europe, fro United States, and forms of it from Ceylon, Singapore, and Java.

Genus COSMARIUM, *Corda*.

19. COSMARIUM DORSITRUNCATUM, (*Nordst.*) *nob.*—C. Scenedesmus, *Delp.*, *var.* dorsitruncatum, *Nordst. in K. Sv. Vet.-Akad. Handl.* xxii. no. 8 (1888), p. 59, t. 3. fig. 15.

C. parvum, circiter 1¼-plo latius quam longum, profundissime constrictum, sinu angustissimo-lineari cum extremo leviter ampliato; semicellulæ depresso-subsemicirculares, angulis basalibus obtusis, apice leviter depresso; a vertice visæ anguste ellipticæ, polos versus leviter attenuatis; a latere visæ circulares; membrana subtilissima punctato-granulata; pyrenoidibus conspicuis *binis*.

Long. 30–32 μ; lat. 38–42 μ; lat. isthm. 12–14 μ; crass. 15–18 μ. (Pl. 4. fig. 4.)

Hab. Yan Yean Reservoir, at the weedy margins (Feb.–Apr., and also Oct. 1905).

This Desmid was described and figured from New Zealand as "*C. Scenedesmus β dorsitruncatum*" by Nordstedt, who was in doubt, however, concerning the nature of the chloroplasts. It has been recorded by Raciborski from the Centenial Park, Sydney (*vide* Rospraw. Wydz. matem.-przyr. Akad. Umiej. Krakow. xxii. (1892) p. 373), and that author states that the chloroplasts contain one pyrenoid. In this statement it would appear that Raciborski is incorrect. The specimens from Victoria were in absolute agreement with Nordstedt's published dimensions and with his figure, but in all cases every semicell possessed a partially subdivided axile chloroplast containing *two conspicuous pyrenoids*.

The cell-wall is most minutely granulate, so that the margin is very slightly rough. These granules are less evident in the centre of the semicells than near the margins.

C. dorsitruncatum differs from *C. depressum*, (Näg.) Lund. (= *C. Scenedesmus*, Delp.) in its narrow, closed sinus, in the semicircular-depressed form of the semicells, in the minute granulation of the cell-wall, and in the presence of two pyrenoids in the chloroplast. The poles of the vertical view are also more attenuated.

From *C. Pseudoscenedesmus*, W. & G. S. West (in Trans. Linn. Soc. ser. 2, Bot. vi. (1902) p. 164, t. 20. fig. 34), it is distinguished by its relatively greater length, its less deep constriction, its thicker vertical view, and by the dense but exceedingly fine granulation of the cell-wall.

Quite recently Gutwinski has described a plant from Java under the name of "*C. dorsitruncatiforme*" (*vide* Bull. Acad. Sci. Cracovie, Nov. 1902, p. 592, t. 38. fig. 35). This is, however, merely one of the common tropical forms (rather small) of typical *C. obsoletum*, (Hantzsch) Reinsch, and is mentioned as occurring in Koh Chang in the Gulf of Siam in Botan. Tidsskr.

xxiv. (1901) p. 87. The same form has been observed by Lütkemüller from Central China.

20. COSMARIUM MONILIFORME, (*Turp.*) *Ralfs*, *Brit. Desm.* 1848, p. 107, t. 17. fig. 6.

Var. LIMNETICUM, *W. & G. S. West*, *Monogr. Brit. Desm.* iii. (1908) p. 23, t. 67. figs. 6, 7.
Long. 49–52 μ; lat. 26–29 μ; lat. isthm. 18 μ. (Pl. **5**. fig. 15.)
Hab. Yan Yean Reservoir, in the plankton and at the weedy margins.
This variety was most abundant in the plankton in March 1907, but it reached its greatest profusion among the weeds in July. Chains of four individuals were not uncommon. The broad isthmus and the thickened poles easily differentiate it from other forms of the species.

21. COSMARIUM AFFINE, *Racib. in Rospraw. Wydz. matem.-przyr. Akad. Umiej. Krakow.* ser. 2, xxii. (1892) p. 363, t. 6. fig. 25.

Var. EXCAVATUM, var. n. (Pl. **5**. fig. 7.)
Var. semicellulis ad medium apicis minute excavatis; membrana glabra.
Long. 16·4 μ; lat. 11·8 μ; lat. isthm. 8·5 μ; crass. 9·3 μ.
Hab. Yan Yean Reservoir, at the weedy margins (Mar. 1905).

22. COSMARIUM TORTUM, *Lagerh. & Nordst. in Wittr., Nordst., et Lagerh. Alg. Exsic.* no. 1486 (1903), fasc. 35, pp. 16, 17 (cum fig.).

Forma TRIGONA, f. n. (Pl. **5**. figs. 3–4.)
Forma cellulis a vertice visis rotundo-trigonis, angulis levissime producto-submamillatis; membrana delicatissime punctulata.
Long. 21–24 μ; lat. 15–16 μ; lat. isthm. 10 μ.
Hab. Yan Yean Reservoir, in the plankton (Feb.-Apr. 1905, very abundant; Jan. and Feb. 1906).
This small species, which might equally well be placed as *Staurastrum tortum*, is a connecting-link between the genera *Cosmarium* and *Staurastrum*. The twisting of the cells at the isthmus is a much commoner and more marked feature of *Staurastrum* than of *Cosmarium*, and the discovery of this trigonal form adds weight to the suggestion that the species would perhaps be better transferred to the former genus.

23. COSMARIUM TJIBENONGENSE, *Gutw. in Bull. Acad. Sci. Cracovie*, Nov. 1902, p. 591, t. 38. fig. 34.

Forma minor, semicellulis plus regulariter elliptico-hexagonis; chromatophoris centralibus cum pyrenoide singulo et lobis compressis radiatis.
Long. 33 μ; lat. 22–23 μ; lat. isthm. 5 μ. (Pl. **4**. fig. 3.)

Hab. Yan Yean Reservoir, at the weedy margin (June 1905).

This deeply constricted *Cosmarium* appears to be referable to *C. tjibenongense*, Gutw., but the specimens possessed more regular semicells than would be inferred from Gutwinski's figure. It seems most closely allied to *C. contractum*, Kirchn., differing in the hexagonal form of the semicells and in its lobed chloroplasts.

24. **Cosmarium perfissum**, sp. n. (Pl. **4**. fig. 2.)

C. parvum, circiter 1¼-plo latius quam longum, profundissime constrictum, sinu aperto (ad apicem angusto sed extrorsum gradatim ampliato); semicellulæ anguste oblongo-ellipticæ, ventre leviter convexiore quam dorso, in medio apicis cum undulis minutissimis binis; a vertice visæ anguste oblongo-ellipticæ, ad medium utrobique leviter inflatis; a latere visæ subcirculares; membrana subtiliter scrobiculato-punctata; pyrenoidibus singulis.

Long. 23–24 μ; lat. 30–31 μ; lat. isthm. 4 μ; crass. 13 μ.

Hab. Yan Yean Reservoir, in the plankton (Mar.–May 1905) and at the weedy margins (Mar.–July and Dec. 1905).

This species is a near relative of *C. depressum*, (Näg.) Lund., but as it possesses very constant characters which readily distinguish it and render it easy of recognition at all times, it is perhaps best to regard it as specifically distinct. A form of *C. Phaseolus* occurred amongst it, but the two Desmids were obviously not the same. *C. perfissum* is distinguished from *C. depressum* by its deeper constriction, its very narrow isthmus, the more open sinus, the presence of the two minute undulations in the middle of each apex, and by the slight inflation on each side of the vertical view. The cell-wall is also more distantly punctated, and the punctulations themselves are larger.

25. **Cosmarium Phaseolus**, *Bréb. in Menegh.* '*Synops. Desm.*,' *Linnæa* (1840), p. 220; *W. & G. S. West*, *Brit. Desm.* ii. (1905) p. 158, t. 60. figs. 12–14.

Forma semicellulis depressis, tumore centrali reducto et minute punctulato.

Long. 28–30 μ; lat. 28–30 μ; lat. isthm. 7 μ; crass. 14·5 μ. (Pl. **4**. fig. 7.)

Hab. Yan Yean Reservoir, at the weedy margins (Mar., Apr., June, July, and Dec. 1905; Jan. 1906).

26. **Cosmarium achondroides**, sp. n. (Pl. **4**. figs. 9–10.)

C. mediocre, circiter tam longum quam latum, profundissime constrictum, sinu ad apicem angusto sed extrorsum valde aperto; semicellulæ subhexagono-ellipticæ, dorso convexiore quam ventre, angulis lateralibus subrotundatis, apice in medio subrecto vel levissime retuso; a vertice visæ ellipticæ; a latere visæ subcirculares; membrana punctata; chromatophoris parietalibus circiter 8 in semicellula unaquaque, tænia unaquaque late et irregulare cum pyrenoide singulo.

Long. 76–80 μ; lat. 72–78 μ; lat. isthm. 16–17·5 μ; crass. 38 μ.

Hab. Yan Yean Reservoir, in the plankton and at the weedy margins throughout the greater part of the year. Among the weeds it was at its maximum abundance in March.

In general appearance *Cosmarium achondroides* somewhat resembles *C. depressum* var. *achondrum*, (Boldt) W. & G. S. West, especially some of the large forms which occur in the British freshwater plankton. It is distinguished, however, by the form of the semicells, which have a more continuously rounded ventral border, and by the peculiar chloroplasts. The latter are disposed as broad parietal bands, with irregular margins. One pyrenoid is present in each parietal chloroplast, but its position relative to the centre of the semicell is very variable.

27. COSMARIUM PSEUDOPROTUBERANS, *Kirchn. Alg. Schles.* 1878, p. 150.

Var. ANGUSTIUS, *Nordst. in K. Sv. Vet.-Akad. Handl.* xxii. no. 8 (1888), p. 58, t. 6. figs. 15, 16.

Long. 28–35 μ; lat. 23–28 μ; lat. isthm. 6–8 μ.

Hab. Yan Yean Reservoir, at the weedy margins (Dec. 1905 and Jan. 1906).

Many of the Desmids recorded as *C. Elfvingii*, Racib. (= *C. hexagonum*, Elfv. *non* Nordst.), should be transferred to this variety of *C. pseudoprotuberans*. The Victorian forms were delicately punctate as in the New Zealand specimens, and some of them possessed the minute papilla at the basal angles of the semicells described by Raciborski in his *C. Elfvingii* var. *saxonicum* (*vide* Pamietnik. Wydz. matem.-przyr. Akad. Umiej. Krakow. xvii. (1889) p. 780, t. 5. fig. 14).

28. COSMARIUM CAPITULUM, *Roy & Biss. in Journ. Bot.* 1886, p. 195, t. 268. fig. 9.

Var. AUSTRALE, *G. S. West, in Victorian Naturalist*, xxii. (1905) p. 71; *in Journ. Bot.* xliii. (1905) p. 253.

Var. ventre semicellulæ minore, angulis capitulis leviter sursum divergentibus.

Long. 16–19 μ; lat. 20–23 μ; lat. isthm. 5·5–6 μ; crass. 8·5–9 μ. (Pl. 5. fig. 6.)

Hab. Yan Yean Reservoir, at the weedy margins and in the plankton from Nov. to July, sometimes very abundant.

The upwardly diverging angles of this variety give the semicells a relatively straighter apex than in the type. The ventral part of the body of the semicell is also much less developed.

It is interesting to note that a stout northern variety of this species (var. *grœnlandicum*, Börgesen) occurs in the plankton of certain lakes in Scotland and in the Faeroë Is.

29. Cosmarium Murrayi, *Playfair, in Proc. Linn. Soc. N. S. Wales*, xxxii. part i. (1907) p. 195, t. 5. fig. 19.

The specimens of this Desmid observed from Victoria were not in strict agreement with either the description or figure given by Playfair. The sinus was rather deeper, and the projecting apex, although widely truncate, possessed somewhat rounder angles and a pair of minute median undulations. From the vertical view the semicells were broadly elliptic, and every individual showed a very small, somewhat faint protuberance at the middle on each side. This minute protuberance is situated nearer the apex than the base of the semicell and is rather more evident in the side view. The basal angles of the semicells are also slightly thickened and projecting, a fact which although faintly indicated in Playfair's figure, is omitted from his description.

Long. 20–21 μ; lat. 17–18 μ; lat. isthm. 5 μ; crass. 10 μ. (Pl. **4**. fig. 5.)

Hab. Yan Yean Reservoir, among weeds at the margin (Nov. 1905).

30. Cosmarium quadratulum, (*F. Gay*) *De Toni, Syll. Alg.* (1889) p. 934. —Euastrum quadratulum, *F. Gay, Monogr. loc. Conj. Montpellier* (1884), p. 58, t. 1. fig. 15.

Long. 12·5–14·5 μ; lat. 11·2–12·7 μ; lat. isthm. 3–3·4 μ. (Pl. **4**. fig. 12.)

Hab. Yan Yean Reservoir, at the weedy margins (Nov. 1905 to Jan. 1906; abundant).

This minute Desmid was observed in great abundance, and as its characters were remarkably constant I think it is best retained as a species. The somewhat peculiar angularity of the semicells and the widely retuse apices are features which at once distinguish it from *C. norimbergense* or any of the forms of *C. Meneghinii.*

31. Cosmarium trachypleurum, *Lund. in Act. R. Soc. Sci. Upsal.* ser. 3, viii. (1871) p. 27, t. 2. fig. 12.

Var. subglabrum, var. n. (Pl. **4**. fig. 11.)

Var. angulis basalibus semicellularum subrectangularibus, granulis in centro semicellularum nullis.

Long. 46 μ; lat. 40 μ; lat. isthm. 14 μ; crass. 23–24 μ.

Hab. Wallaby Creek Weir, in the plankton (July 1907).

This variety differs from all other described forms of *C. trachypleurum* in the entire absence of the central granules.

32. COSMARIUM SUBTRIORDINATUM, *W. & G. S. West, in Journ Bot.*, April (1897), p. 122, t. 368. fig. 11.

Forma ad var. *rotundatum*, Schmidle, accedens, sinu extrorsum plus ampliato; granulis magnis (vel verrucis) paucis 8–9 in centro semicellularum in seriebus verticalibus multe irregularibus tribus.

Long. 24 μ; lat. 24 μ; lat. isthm. 6·5 μ; crass. 14·5 μ. (Pl. 4. fig. 6.)

Hab. Yan Yean Reservoir, in the plankton (Feb. and Mar. 1905, and Feb. 1906) and at the weedy margins (Mar.–May, Nov. and Dec. 1905, and Jan. 1906).

This *Cosmarium* was never abundant, but for about six months it occurred sparingly in the weed collections. It differs from the original African form principally in the more open sinus, in which feature it agrees with the var. *rotundatum* described by Schmidle from Zanzibar and Mozambique (*vide* Engler, Bot. Jahrbüch. xxvi. (1898) p. 36, t. 2. fig. 21).

33. COSMARIUM AMŒNUM, *Bréb. in Ralfs, Brit. Desm.* (1848) p. 102, t. 17. fig. 3.

Var. MEDIOLÆVE, *Nordst. in K. Sv. Vet.-Akad. Handl.* xxii. no. 8 (1888), p. 50, t. 5. fig. 12.

Long. 45–54 μ; lat. 26–32 μ; lat. isthm. 9–10·5 μ; crass. 16·5–17·5 μ.

Hab. Yan Yean Reservoir, at the weedy margins.

This Desmid was fairly general throughout the year at the weedy margins of the lake, reaching its greatest abundance in February. It was also frequent at Heidelberg, Victoria, in March 1905. The specimens were in all cases smaller than those described from New Zealand, having dimensions more in accordance with the typical plant. The granules of this variety are much smaller than in the type form, and not only are they wanting in the centre of the semicells, but their arrangement is quite different.

34. COSMARIUM HARDYI, *G. S. West, in Victorian Naturalist*, xxii. (1905) p. 72; *in Journ. Bot.* xliii. (1905) p. 253.

C. mediocre, circiter 1½-plo longius quam latum, profunde constrictum, sinu breviter lineari extremo ampliato et extrorsum valde aperto; semicellulæ subsphærico-semicirculares, lateribus et angulis inferioribus late rotundatis granulis minutis subpapilliformibus instructis, apice levissime truncato et glabro, intra margines laterales et infra apicem granulis minutissimis irregulariter ordinatis præditæ; in parte magna mediana semicellularum cum scrobiculis confertis quincuncialiter ordinatis; a latere visæ subsphæricæ, apice subdepresso-truncato; a vertice visæ late ellipticæ et latissime tumidæ utrobique, polis granulato-subpapillatis, lateribus scrobiculatis.

Long. 84–89 μ; lat. 56–61 μ; lat. isth. 20–22 μ; crass. 50–52 μ. (Pl. 4. fig. 8.)

Hab. Yan Yean Reservoir, in the plankton throughout most of the year (very common in Apr. 1905 and Feb. 1906); also rare at the weedy margins (Apr. and May, 1905).

Cosmarium Hardyi is a very characteristic species. The form of its semicells, with their granulate lower margins, and the numerous central scrobiculations easily distinguish it from any others with which it might be confused. Its great thickness is also a distinctive feature.

35. COSMARIUM AMPLUM, *Nordst. in Bot. Notis.* (1887) p. 163; *l. c.* (1888) p. 63, t. 6. fig. 20.

Long. 130–135 μ; lat. 92–97 μ; lat. isthm. 28–29 μ.

Hab. Pool in the Yan Yean Catchment area, common (Sept. 1907).

Genus XANTHIDIUM, *Ehrenb.*

36. XANTHIDIUM HASTIFERUM, *W. B. Turn. in Journ. Roy. Micr. Soc.* ser. 2, v. (1885) p. 938, t. 15. fig. 20.—X. Antilopæum *var.* angulatum, *Josh.* (1886).

Forma cellulis latioribus, apicibus paullo elevatis; spinis apicalibus reductis, singulis vel binis, nonnunquam papillatis vel rarissime nullis.

Long. s. spin. 45–46 μ; lat. s. spin. 48–50 μ, c. spin. 85–98 μ; lat. isthm. 10–11 μ.

Hab. Yan Yean Reservoir, in the plankton (Mar. and April, 1905) and at the weedy margins (Mar., May, and June, 1905).

This form is of interest as it connects the typical plant with the New Zealand var. *inevolutum*, Nordst. (K. Sv. Vet.-Akad. Handl. xxii. no. 8 (1880), p. 43, t. 4. fig. 24). It is quite possible that the semicell upon which Nordstedt founded his New Zealand variety belongs to the same form as the Victorian specimens, as semicells of the latter were occasionally destitute of the shorter apical spines.

Genus ARTHRODESMUS, *Ehrenb.*

37. ARTHRODESMUS INCUS, (*Bréb.*) *Hass. Brit. Freshw. Alg.* (1845) p. 357; *Ralfs, Brit. Desm.* (1848) p. 118, t. 20. figs. 4 *a–d*.

Two forms were noticed in moderate abundance.

Forma *a*. Large form of fairly typical shape, with strong divergent spines.

Long. s. spin. 25 μ; lat. s. spin. 26–28 μ, c. spin. 53–56 μ; lat. isthm. 6 μ.

Forma *b*. Small form somewhat resembling *A. phimus*, W. B. Turn., var. *occidentalis*, W. & G. S. West (in Trans. Roy. Irish Acad. xxxii. (1902) p. 58, t. 2. fig. 17), but with a straight apex.

Long. 16 μ; lat. s. spin. 17–18 μ, c. spin. 22–23 μ; lat. isthm. 4·5–5 μ.

Hab. Yan Yean Reservoir. Both forms occurred in the plankton and at the weedy margin of the lake; forma *a* was much more frequently met with than forma *b*.

38. ARTHRODESMUS TRIANGULARIS, *Lagerh. in Öfvers. K. Vet.-Akad. Förh.* xlii. (1885) p. 244, t. 27. fig. 22.

Forma MINOR. [= *A. Incus*, forma, *Racib. in Rospraw. Wydz. matem.-przyr. Akad. Umiej. Krakow.* ser. 2, xxii. (1892) p. 377, t. 7. fig. 25; A. Incus, *forma* Saidæ, *Eich. & Racib. ibid.* xxvi. (1893) p. 120.]

Long. 17–18 μ; lat. s. spin. 11·5–12·5 μ, c. spin. 35–37·5 μ; lat. isthm. 4 μ.

Hab. Yan Yean Reservoir, in the plankton and at the weedy margin.

Genus STAURASTRUM, *Meyen.*

39. STAURASTRUM MUCRONATUM, *Ralfs, in Ann. Nat. Hist.* (1845) p. 152, t. 10. fig. 6.

Var. DELICATULUM, *G. S. West, in Victorian Naturalist*, xxii. (1905) p. 72; *in Journ. Bot.* xliii. (1905) p. 254.

Var. semicellulis elliptico-fusiformibus, angulis lateralibus submamillatis et delicatissime apiculatis.

Long. 32·5–35 μ; lat. 34–37 μ; lat. isthm. 6–7 μ. (Pl. **5.** fig. 5.)

Hab. Yan Yean Reservoir, in the plankton (very common, Feb. and Mar. 1905) and at the weedy margins (very rare, May and July, 1905).

40. STAURASTRUM MUTICUM, *Bréb. in Menegh. Synops. Desm., Linnæa* (1840) p. 228; *in Ralfs, Brit. Desm.* (1848) p. 125, t. 21. fig. 4, t. 34. fig. 13.

Var. VICTORIENSE, *G. S. West, in Vict. Nat. l. c.*; *Journ. Bot. l. c.*

Var. cellulis longioribus quam in forma typica; semicellulis late ellipticis; membrana delicatissime punctata.

Long. 30 μ; lat. 20·5 μ; lat. isthm. 7·5 μ. (Pl. **5.** fig. 8.)

Hab. Yan Yean Reservoir, in the plankton (most abundant from Mar. to May, 1905) and at the weedy margins (common in June, 1905).

41. STAURASTRUM DIGITATUM, sp. n. (Pl. **5.** figs. 11–12.)

S. parvum, circiter $1\frac{2}{3}$-plo latius quam longum (cum processibus), leviter constrictum, sinu minuto; semicellulæ subglobosæ, cum processibus elongatis glabris et leviter divergentibus apicem versus utroque, processu unoquoque gradatim attenuato sed constrictione minuto ad basin, apicibus processuum obtusis; a vertice visæ corpore circulari, cum processibus elongatis glabris 4–5-radiatis; membrana tenue et glabra.

Long. s. proc. 19–21 μ, c. proc. 30–32 μ; lat. s. proc. 12–13 μ, c. proc. 48–52 μ; lat. isthm. 8–9·5 μ.

Hab. Yan Yean Reservoir, at the weedy margins (Mar. and Apr. 1905).

This species is a close ally of *S. lævispinum*, Bissett, *S. sublævispinum*, W. & G. S. West, and *S. subnudibrachiatum*, W. & G. S. West. It stands nearest to *S. lævispinum* var. *tropicum*, W. & G. S. West. (in Ann. Roy.

Bot. Gard. Calcutta, vi. (1907) p. 215, t. 16. fig. 1), which is known from Burma, but differs in the more elongated processes, each of which is constricted at the base, and in the proportionately smaller body of the semicells. In all forms of *Staurastrum lævispinum* the processes gradually merge into the body of the semicell from a dilated base, whereas in *S. digitatum*, as in *S. victoriense*, the processes are narrowed at the base and attached at definite points to the body of the semicell.

The cell-wall is very thin, and the processes are hollow, a lobe of the chloroplast passing into each process and extending almost to its apex.

42. STAURASTRUM VICTORIENSE, sp. n. (Pl. **5**. figs. 13–15.)—S. nudibrachiatum, *Borge*, *var.* victoriense, *G. S. West*, *in Victorian Naturalist*, xxii. (1905) p. 72 ; *in Journ. Bot.* xliii. (1905) p. 253.

S. mediocre, circiter 1½-plo latius quam longum (cum processibus), levissime constrictum, sinu minimo vix conspicuo ; semicellulæ subhemisphærico-globosæ, apice valde convexo (non depresso in parte mediana), corona processuum longorum leviter sursum divergentium 10–11 præditæ ; processibus rectis glabrisque, ad basin leviter constrictis et apicem versus gradatim attenuatis, apicibus processuum integris et obtuse conicis ; a vertice visæ circulares, processibus glabris 10–11-radiatis ; chromatophoris ut in *S. nudibrachiato* ; membrana corporis subtiliter et irregulariter punctata, membrana processuum tenuiore et glabra.

Long. s. proc. 45–46 μ ; lat. sine proc. 35–36·5 μ, c. proc. 79–96 μ ; lat. isthm. 31 μ ; crass. proc. 4·8–5·8 μ ; long. proc. 25–34 μ.

Hab. Yan Yean Reservoir, in the plankton (somewhat scarce throughout the entire year) and at the weedy margins (April–July, 1905 ; common in June and July).

This curious species stands nearest to *S. nudibrachiatum*, Borge (in Arkiv Botan. K. Sv. Vet.-Akad. Bd. i. (1903) p. 109, t. 4. fig. 20), a Desmid recently described from Brazil ; but as the characters of the Victorian plant are remarkably constant, and it can be so easily distinguished from the Brazilian plant, I have thought it advisable to place it as a distinct species.

The Australian species differs from the Brazilian one in the proportionately longer body of the cells, the slighter constriction, the narrower processes *with entire apices*, and in the greater number of processes on each semicell.

No specimens were observed with any trace of teeth at the apices of the processes. The walls of the processes are much thinner than those of the body of the *Staurastrum*, and are perfectly smooth, whereas the rounded semicells are distinctly punctate. Each process is slightly constricted at the base, the widest part being about one-third the length from the base. All the specimens seen were either 10- or 11-radiate in vertical view.

Compare also with *S. subnudibrachiatum*, W. & G. S. West.

43. STAURASTRUM LÆVISPINUM, *Biss. in Journ. Roy. Micr. Soc.* (1884) p. 195, t. 5. fig. 5.

Var. SUBBRACHIATUM, *G. S. West, in Victorian Naturalist*, xxii. (1905) p. 72; *in Journ. Bot.* xliii. (1905) p. 253.

Var. processibus angustioribus basin versus et sæpe emarginato-furcatos ad apices.

Long. s. proc. 17–18·5 μ, cum proc. 30–35 μ; lat. 11–12 μ, c. proc. 30–32 μ; lat. isthm. 6·5–7 μ. (Pl. **5**. fig. 10.)

Hab. Yan Yean Reservoir, in the plankton (Mar. and Apr. 1905).

This variety is distinguished by the greater differentiation which exists between the processes and the body of the semicells. Some or all of these processes are often emarginate at the apex.

It should be compared with *S. lævispinum* forma *sydneyensis*, Racib. (in Rospraw Wydz. matem.-przyr. Akad. Umiej. Krakow. xxii. (1892) p. 379, t. 7. fig. 10).

44. STAURASTRUM SENARIUM, (*Ehrenb.*) *Ralfs, Brit. Desm.* 1848, p. 216; *Wolle, Desm. U. S.* 1884, p. 147, t. 52. fig. 1; *W. B. Turner, in K. Sv. Vet.-Akad. Handl.* Bd. 25, no. 5 (1893) p. 119, t. 15. fig. 13.—S. pseudopisciforme, *Eichl. & Gutw.*, var. denticulatum, *Lütkem. in Ann. k. k. Nat. Hofmus. Wien*, Bd. xv. (1900) p. 124, t. 6. figs. 37, 38.

Long. 42–46 μ; lat. c. proc. 46–58 μ; lat. isthm. 11–15 μ. (Pl. **6**. fig. 13.)

Hab. Yan Yean Reservoir, in the plankton (Mar.–May, 1905) and at the weedy margins (Mar.–July, 1905).

Much doubt prevails concerning the exact identity of *Staurastrum senarium*, although it is generally accepted as a species closely akin to *S. furcatum*, Ehrenb., but provided with twelve accessory processes in place of the six which are so characteristic of the latter species. The Australian plants reached their maximum abundance in April. Six of the accessory processes were in the same plane as the three angular processes, and six were apical. The angles of the semicells were gradually produced into a slightly divergent process which was either quite smooth or furnished with a ring of four small denticulations. The presence of these denticulations is a feature of little importance, as they may be present on the angular processes of one semicell, but absent from those of the other.

45. STAURASTRUM PATENS, *W. B. Turn. in K. Sv. Vet.-Akad. Handl.* Bd. 25, no. 5 (1893) p. 108, t. 14. fig. 21.

Var. PLANCTONICUM, *G. S. West, in Victorian Naturalist*, xxii. (1905) p. 73; *in Journ. Bot.* xliii. (1905) p. 254.—S. patens f. australica, *Playfair, in Proc. Linn. Soc. N. S. Wales*, xxxii. pt. 1 (1907), p. 189, t. 5. fig. 9.

Var. paullo minor, angulis leviter productis trispinatis; semicellulæ a vertice visæ lateribus subrectis, angulis leviter productis et trispinatis.

Long. s. spin. 32 μ, c. spin. 52–56 μ; lat. s. spin. 38–44 μ, c. spin. 58–66 μ; lat. isthm. 11·5 μ. (Pl. **6**. fig. 14.)

Hab. Yan Yean Reservoir, in the plankton (Feb.–May, 1905).

Judging by the front view only the Australian forms are unquestionably *Staurastrum patens*, W. B. Turn., but the drawing given by Turner of the vertical view does not seem to me to be correct. Assuming this to be the case, the only striking difference between the Australian and Indian forms is the presence of three large spines instead of two at each angle. The elevated triangular platform on the apex of each semicell is furnished with a pair of denticulations near each angle and within the lateral margins. This same variety has also been described by Playfair (under the name of "forma *australica*") from New South Wales.

S. patens should be compared with *S. Freemanii* var. *triquetrum*, W. & G. S. West ('Freshw. Alg. Ceylon,' Trans. Linn. Soc. ser. 2, Bot. vi. (1902) p. 177, t. 21. fig. 22).

S. javanicum, Gutw. ('Alg. Java,' Bull. de l'Acad. Sci. Cracovie (1902) p. 604, t. 39. fig. 59), does not differ sufficiently from *S. patens* to warrant separation as a distinct species.

46. STAURASTRUM UNICORNE, *W. B. Turn. l. c.* p. 107, t. 15. fig. 16.

Var. NODIFERUM, (*W. B. Turn.*) *W. & G. S. West, in Trans. Linn. Soc.* ser. 2, *Bot.* vi. (1902) p. 175.—S nodiferum, *W. B. Turn. l. c.* p. 130, t. 14. fig. 26.

Forma minor, aculeis curvatis 4–5 ad capitulos processuum; semicellulæ a vertice visæ lateribus subrectis et constrictione infra angulos capitatos prominentiore.

Long. c. spin. 18–20 μ; lat. c. spin. 18–19 μ; lat. isthm. 4 μ. (Pl. **3**. fig. 11.)

Hab. Yan Yean Reservoir, at the weedy margins (Mar. 1905).

S. unicorne appears to be a species with an eastern distribution, and the extension of a small form of it as far south as Victoria is decidedly interesting. The extreme forms of the species are rather different in appearance, but the connecting forms are numerous and include a large series of intermediate states.

The form under consideration is the smallest yet found, and differs from all other known forms in the straightness of the sides of the vertical view. From four to five curved aculei are attached to each capitate angle.

47. STAURASTRUM STRIOLATUM, (*Näg.*) *Archer, in Pritch. Infus.* (1861) p. 740; *Nordst. in Vidensk. Medd. Naturh. Foren. Kjöbenh.* (1869) p. 225, t. 4. fig. 45.

Long. 21–23 μ; lat. 21–24·5 μ; lat. isthm. 7–8 μ; diam. zygosp. 37–39 μ; crass. zygosp. 24 μ. (Pl. **6**. figs. 10–12.)

Hab. Ottelia Creek, Yan Yean Reservoir, in pools (3 Sept. 1907).

Several zygospores of this species were observed, and they were of a type most unusual in the genus *Staurastrum*. They were considerably flattened or compressed, being oblong in the side view, but having a circular outline in the front view with 10–12 prominent marginal undulations. These undulations were not caused by wart-like elevations but by ridges extending from one flattened side to the other.

Wittrock has described a similar zygospore from Öland which he referred to *S. striolatum* var. *oelandicum* (*vide* Wittr. in Bih. till K. Sv. Vet.-Akad. Handl. Bd. i. no. 1 (1872) p. 52), but I can see no essential differences between Wittrock's variety and typical *S. striolatum*.

The zygospore of *S. dilatatum*, as described by Messrs. Roy and Bissett, is of a similar nature to that of *S. striolatum*, but, according to Ralfs, that of *S. alternans* is globular and furnished with forked spines.

48. STAURASTRUM NEGLECTUM, sp. n. (Pl. **3**. fig. 12.) S. tricorne, (*Bréb.*) *Menegh. var. β, Ralfs, Brit. Desm.* (1848) p. 134, t. 34. figs. 8 *b*, *c*, *d*.

S. parvum, 1¼–1½-plo latius quam longum (cum processibus), minutissime (vix conspicue) constrictum; semicellulæ parte basali breviter cylindrica, parte superiore incudiformi apice convexo, angulis in processus attenuatos minute denticulatos horizontaliter dispositos productis; a vertice visæ triangulares, lateribus corporis parvæ concavis, angulis in processus attenuatos sublongos rectus vel leviter curvatos productis; processibus cum annulis denticulorum minutorum 6–7 præditis, apices versus leviter dilatatis et apicibus tridenticulatis; cellulæ plerumque tortæ, nonnunquam processibus alterius semicellulæ cum iis alterius alternantibus.

Long. 23·5–26 μ; lat. c. proc. 32–35 μ; lat. med. cell. 6·5–7 μ.

Hab. Yan Yean Reservoir, among weeds at the margin (Jan. 1906), and in pool in the catchment area (Sept. 1907).

This species differs from *S. hexacerum*, (Ehrenb.) Wittr. (=*S. tricorne*, as described and figured by Ralfs), in the smaller body of the semicells, the cylindrical median part of the cells, with the faintest indication of a constriction, and in the more elongate processes. The latter are also much more elegant and are dilated towards the extremities. Ralfs figured the zygospores of both *S. hexacerum* and *S. neglectum* (=*S. tricorne*, var. *β*, Ralfs), and that of the latter is distinguished by the repeated furcation of the extremities of the spines (*vide* Ralfs, Brit. Desm. t. 34. fig. 8 *d*).

S. neglectum is widely distributed, although rare, in the British Islands, and I have also examined specimens from Maine in the United States.

49. STAURASTRUM BIBRACHIATUM, *Reinsch, Contrib. Alg. et Fung.* (1875) p. 85, t. 16. fig. 2.

Var. CYMATIUM, *W. & G. S. West, in Trans. Linn. Soc.* ser. 2, *Bot.* v. (1895) p. 74, t. 8. fig. 28.

Cellulæ plerumque tortæ; long. cum proc. 35–39 μ; lat. cum proc. 39–44 μ; lat. isthm. 4·5 μ; crass. 7·5–8 μ. (Pl. **6**. figs. 15–16.)

Hab. Yan Yean Reservoir, at the weedy margins (July, Nov., and Dec. 1905; Jan. 1906).

This peculiar *Staurastrum* was particularly common in July. The specimens agreed very well with those originally described from Madagascar, but the cells in nearly all cases were twisted at the isthmus, and the processes were minutely tridenticulate. Bohlin has recorded this *Staurastrum* from the Azores (*vide* Bohlin, in Bih. till K. Sv. Vet. -Akad. Handl. Bd. 27, no. 4 (1901) p. 55, fig. 13), but was greatly in error in regarding it as allied to *S. gracillimum* var. *biradiatum*, W. & G. S. West. The Desmid which Bohlin mentions and figures under the name of *S. gracillimum* var. *biradiatum* is typical *S. tetracerum*, Ralfs, and there is little question that *S. bibrachiatum* var. *cymatium* has had a direct origin from *S. tetracerum*. Specimens in which one semicell agrees with *S. tetracerum* are occasionally observed (Pl. **6**. fig. 15; also Bohlin, *l. c.* fig. 13), and the denticulation of the processes is the same. The marked twisting of the cells at the isthmus is also a character in common with *S. tetracerum*.

50. STAURASTRUM EXCAVATUM, *W. & G. S. West, in Trans. Linn. Soc.* ser. 2, *Bot.* v. (1895) p. 78, t. 8. fig. 42.

Forma isthmo cellularum breviore et sinu minore, processibus cum undulis numerosioribus; cellulis tortis.

Long. (max.) 15–25 μ; lat. s. proc. circ. 7–8·5 μ; c. proc. 34–47 μ; lat. isthm. 4–5 μ; crass. 5·5 μ. (Pl. **6**. figs. 19–20.)

Hab. Yan Yean Reservoir, in the plankton and at the weedy margins; very common in the plankton, Jan. and Feb. 1906; abundant among the weeds, Mar., Nov., and Dec. 1905.

The specimens were almost invariably twisted at the isthmus, and the processes showed much variation in length. The species bears a considerable resemblance to *S. tetracerum*, Ralfs, but the broad excavation at the apex of each semicell and the more horizontally disposed processes easily distinguish it.

51. STAURASTRUM HARDYI, sp. n. (Pl. **6**. figs. 21–22.)

S. parvum, pæne duplo latius quam longum cum processibus, modice constrictum; semicellulæ subcampanulatæ (vel incudiformes e basi subangusta), parte basali subcylindrica et angulis basalibus leviter rotundatis, apice leviter triundulato, angulis superioribus in processus longos attenuatos horizontaliter dispositos productis, marginibus processuum nodulosis, apicibus processuum minute tridenticulatis; a vertice visæ fusiformes, corpore elliptico, polis in processus sublongos rectos attenuatos gradatim productis, marginibus processuum undulatis; membrana glabra.

Long. 21–24 μ; lat. c. proc. 39–43 μ; lat. isthm. 5–5·5 μ; crass. 9–9·5 μ.

Hab. Yan Yean Reservoir, at the weedy margins (July, Nov., and Dec. 1905; Jan. 1906).

This small species, which occurred abundantly in November and December, appears at first sight to have no very distinctive peculiarities. It is most nearly related to *Staurastrum undulatum*, W. & G. S. West (in Trans. Linn. Soc. ser. 2, Bot. v. (1895) p. 78, t. 8. fig. 37), and *S. exile*, W. & G. S. West (*l. c.* fig. 38), two species described from Madagascar, but is larger than either of them, with more finely nodulose processes, a more expanded apical region of the semicells, and a fusiform vertical view.

S. Hardyi was also frequent in a lagoon of the Yarra-Yarra River (Mar. 1905).

52. STAURASTRUM ASSURGENS, *Nordst. in K. Sv. Vet.-Akad. Handl.* Bd. xxii. no. 8 (1888), p. 37, t. 4. fig. 8.

Var. VICTORIENSE, var. n. (Pl. **6**. fig. 17.)

Var. minus, verrucis dorsalibus majoribus prominentioribusque; semicellulis a vertice visis angustioribus, sine tumore utrobique.

Long. 35–37 μ; lat. cum proc. 75–80 μ; lat. isthm. 7·5–8·5 μ; crass. 16·5 μ.

Hab. Yan Yean Reservoir, somewhat rare in the plankton, but abundant at the weedy margins (1905–6).

A curious monstrosity of this variety was observed which possessed four "semicells" united at a central point. Each "semicell" was quite normal in character, and the monstrosity is unique. The specimen was fully grown and I can offer no suggestion as to its origin unless it represents an abnormal growth from a zygospore. It would appear impossible for *cell-division* in the Desmidiaceæ to give rise to such a monstrosity.

—— —— Forma major; processibus elongatis et patentioribus.

Long. 57 μ; lat. c. proc. 148–160 μ. (Pl. **6**. fig. 18.)

Only two specimens of this large form were seen amongst a multitude of smaller ones.

It should be mentioned here that Playfair (Proc. Linn. Soc. N. S. Wales, xxxii. (1907) p. 192) has expressed some extraordinary views about "young forms" of *S assurgens* which are contrary to all known facts concerning the Desmidiaceæ.

53. STAURASTRUM INDENTATUM, *W. & G. S. West, in Trans. Linn. Soc.* ser. 2, *Bot.* vi. (1902) p. 186, t. 22. figs. 10–12.

Forma dorso semicellularum minus dentato; semicellula a vertice visa paullo angustiore.

Long. 38–41 μ; lat. c. proc. 65–73 μ; lat. isthm. 8–9·5 μ; crass. 12 μ.

Hab. Yan Yean Reservoir, in the plankton and at the weedy margins (1905).

This species was originally described from Ceylon, and the Australian specimens only differ in the less prominent denticulate warts at the apices of the semicells, and in the less inflated body of the semicell as seen in vertical view. Playfair has expressed the opinion that *Staurastrum indentatum* is an "immature form" of *S. assurgens*, Nordst., but he does not appear to have recognized the fundamental differences between these species.

54. STAURASTRUM LONGIRADIATUM, *W. & G. S. West, in Trans. Linn. Soc.* ser. 2, *Bot.* v. (1896) p. 267, t. 17. fig. 23.

Var. SUBNUDUM, var. n. (Pl. **6**. fig. 23.)

Var. parte basali semicellulæ leviter subrectangulari, apice sine verrucis emarginatis et levissime concavo, apicibus processuum subtrifurcatis; semicellulis a vertice visis fusiformibus, corpore elliptico.

Long. 30–31 μ; lat. c. proc. 68–76 μ; lat. isthm. 6·5–8 μ; crass. 11 μ.

Hab. Yan Yean Reservoir, at the weedy margins (Nov. and Dec. 1905, and Jan. 1906).

This variety occurred abundantly in Dec. 1905, and also occurred in the collections made in the preceding and following months. The type form of the species was never so abundant, but at the same time it was found in the material from April 1905 to Jan. 1906, and occurred in plenty in the plankton throughout the greater part of the year.

55. STAURASTRUM ZONATUM, *Börges. in Vidensk. Medd. Naturh. Foren. Kjöbenhavn* (1890), p. 46, t. 5. fig. 48.

Long. s. proc. 34 μ, c. proc. 42–44 μ; lat. c. proc. 48–56 μ; lat. isthm. 10 μ.

Hab. Pool in the Yan Yean catchment area, frequent (Sept. 1907). Previously known from Brazil, and a variety of it from Ceylon.

Genus SPHÆROZOSMA, *Corda.*

56. SPHÆROZOSMA WALLICHII, *Jacobsen, in Botan. Tidsskrift*, viii. (1876) p. 211.

Forma AUSTRALIS, f. n. (Pl. **3**. fig. 3.)

Forma duplo-minor, lateribus semicellulæ rectis et parallelis cum denticulis prominentibus tribus.

Long. 8 μ; lat. c. dentic. 8·5 μ; lat. isthm. 4 μ.

Hab. Yan Yean Reservoir, at the weedy margins, very rare (July 1905).

In this form the lateral margins of the semicells are quite straight and furnished with three denticulations, one at each angle and one in an intermediate position.

Order PROTOCOCCOIDEÆ.

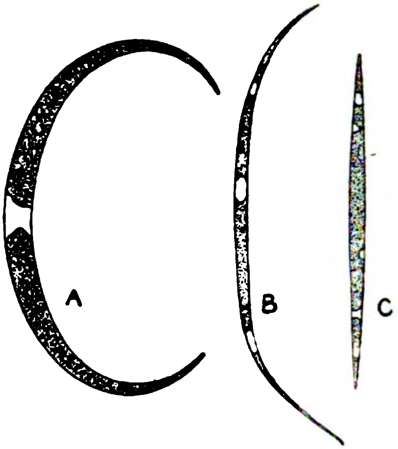
Family **PROTOCOCCACEÆ** (or **AUTOSPORACEÆ**).

Genus ANKISTRODESMUS, *Corda.*

57. Ankistrodesmus falcatus, (*Corda*) *Ralfs*, *Brit. Desm.* (1848) p. 180, t. 34. fig. 3 ; *G. S. West*, *Treatise Brit. Freshw. Alg.* 1904, p. 221.

Two curious forms of this plant were observed. One, from the May weed-collections of the Yan Yean Reservoir (1905), was strongly arcuate with incurved extremities : lat. 7 μ ; long. max. 94 μ ; apic. inter se distantibus 68 μ. (Text-fig. 8, A.)

Fig. 8.



A and B. Two forms of *Ankistrodesmus falcatus*, (Corda) Ralfs ; C. *A. falcatus* var. *acicularis*, (A. Br.) G. S. West. All × 500. B and C show fragmentation of the chloroplast.

The other form was almost straight in the middle, but strongly incurved at the extremities, which were much attenuated. The chloroplast was divided into four segments : long. 116 μ; lat. 3·2 μ. (Text-fig. 8, B.)

Genus LAGERHEIMIA, *Chodat.*

58. Lagerheimia splendens, sp. n. (Pl. 6. figs. 4–8.)

L. conspicua et solitaria ; cellulæ cylindricæ cum polis obtuse conicis ; setis sublongis, rectis vel curvatis, 3–4 juxta sed infra polum unumquemque, tuberculis expansis et conspicuis ad basin setarum ; membrana cellularum sparse et levissime spirostriolata ; chromatophora singula parietali, sine pyrenoide (?).

Long. cell. 28–38 μ; lat. cell. 7·5–9 μ; long. set. 13–26 μ.

Hab. Yan Yean Reservoir, in the plankton (Feb. 1906, scarce).

This large and conspicuous *Lagerheimia* possesses cells which are almost three times the size of those of any other species. The outward form of the cells, with conical poles, is also quite distinctive. The bristles are most distinctly tuberculated at the base, the flattened tubercles being closely applied to the sloping sides of the poles and never at the extreme apex. The number of bristles attached to each pole is either three or four, and not uncommonly three are present at one pole and four at the other pole of the same individual. The bristles are readily detached from the cells, the tuberculated base leaving a minute scar on the conical pole from which it has become detached. The cell-wall is delicately marked with a few decussating spiral striations, which can be seen very well in some of the empty cells. There is a single parietal chloroplast, which only covers part of the wall of the cell, and, so far as could be ascertained, it contained no pyrenoids.

Genus OOCYSTIS, *Näg.*

59. Oocystis submarina, *Lagerh. in Botan. Notiser* (1886), p. 45, fig. 1.

Forma major: long. cell. 23–25 μ; lat. cell. 7·5–8 μ.

Hab. Yan Yean Reservoir, at the weedy margins (Mar. 1905).

O. submarina was described by Lagerheim from brackish ditches in Sweden. In the form of the cells the Australian plant exactly agrees with it, but the dimensions are larger. The colonies observed consisted of either two or four cells.

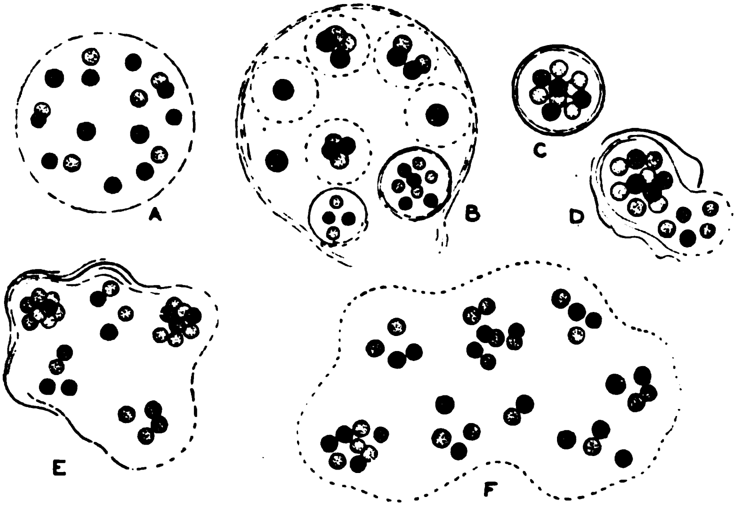
Family **PALMELLACEÆ.**

Genus TETRASPORA, *Link.*

60. Tetraspora lacustris, *Lemm. in Botan. Centralbl.* (1898) lxxvi.; *in Forschungsber. Biol. Stat. Plön*, vii. (1899) p. 23, t. 1. fig. 13.

I have for some time regarded *Tetraspora lacustris*, Lemm., as most probably merely a stage in the life-history of *Sphærocystis Schröteri*, Chodat (*vide* Treat. Brit. Freshw. Alg. 1904, p. 242), and the Yan Yean plankton-collections furnish much evidence in support of this view. From February to September the plankton contained colonies of a green Alga which is unquestionably referable to *Sphærocystis Schroeteri*. These colonies reached their maximum abundance from June to July, and best exhibited the characteristic features of *Sphærocystis* from May to June. In July the larger colonies became mostly dissociated into the component smaller groups, which then developed more conspicuous gelatinous coats with much firmer outer envelopes. In September many of these small colonies became irregular, and in October all of them were irregular and a considerable range in size was evident. The investments of the larger colonies, which reached a diameter of 200 μ, were very gelatinous and inconspicuous. Among these larger colonies were colonies of an intermediate size, which could be seen clearly arising by further cell-division from the small groups with tough envelopes. This growth was accompanied by the extension of the inner, more gelatinous coats of mucus, as the outer, firmer coats were exfoliated. The second, irregular type of colony was abundant from October to December, reaching its maximum abundance in November, and it appears to me that it must be regarded as identical with the Alga described by Lemmermann as *Tetraspora lacustris*.

Fig. 9.



A—F. Stages in the life-history of *Sphærocystis Schroeteri* as seen in the plankton of the Yan Yean Reservoir. ×300.

A and B, typical *Sphærocystis*-stage; C, group of daughter-cells escaped from larger colony; D, growth of colony C by exfoliation of tougher outer membranes; E, further advanced; F, *Tetraspora*-stage.

The different colonies described above are stages in the life-history of one Alga, the *Sphærocystis*-type of colony flourishing from February to August, and then giving rise to the imperfect *Tetraspora*-type, which is abundant from September to December. No trace of the Alga was observed in the January collections.

Class **BACILLARIEÆ.**

Order CENTRICÆ.

Family **RHIZOSOLENIACEÆ.**

Genus RHIZOSOLENIA, *Ehrenb.*

61. Rhizosolenia morsa, *W. & G. S. West, in Trans. Roy. Irish Acad.* xxxiii. sect. B (1906), p. 109, t. 11. figs. 5–7.—R. eriensis, *H. L. Smith*, var. morsa, *W. & G. S. West, in Trans. Roy. Soc. Edin.* xli. part iii. (1905) p. 509, t. 6. fig. 23.

Lat. valv. 5–9 μ; long. set. 18–22 μ. (Pl. **3**. figs. 15–16.)

Hab. Yan Yean Reservoir, in the plankton (Jan. 1906).

This Diatom was not uncommon in the January plankton, but no trace of it was observed in any of the other collections. It thus appears in the plankton only when the temperature of the surface water is at its highest (74° F. = 23·3° C.). In the possession of the peculiar excavated extremities the specimens exactly agreed with those which occur in the summer plankton of the lakes of the western British area, but they were all proportionately smaller with shorter bristles.

It is probable that the vegetative period of *R. morsa* lasts only for about five or six weeks in the warmest part of the year, and as I have never yet seen a single individual except from a purely limnetic habitat, the vegetative phase appears to be confined to the plankton. At its conclusion, resting-spores are formed, which presumably remain dormant for an extended period until the requisite conditions for germination again supervene, but practically nothing is known concerning the resting-spores during the lengthy period they appear to be quiescent.

Order PENNATÆ.

Family **EUNOTIACEÆ.**

Genus EUNOTIA, *Ehrenb.*

62. Eunotia major, (*W. Sm.*) *Rabenh.*, var. bidens, (*Greg.*); *Van Heurck, Synops. Diat. Belg.* t. 34. fig. 15.—Himantidium bidens, *Greg.*

This Diatom was very common among the Yan Yean weeds, and the valves exhibited a great variability of size. Some of the tiny specimens were only 36 μ in length, whereas the largest reached a length of 158 μ, a much more normal size for forms of *Eunotia major*.

One form was noticed with four undulations instead of the two wide ones on the dorsal margin. As this feature at once marks it off from all the biundulate forms, it might stand as forma *quadriundulata*. Long. 88 μ; lat. med. 12 μ; lat. apic. 8·5 μ.

63. Eunotia crispula, sp. n. (Pl. **3**. fig. 14.)

E. submediocris, cellula ut in visa aspectu valvulari subelongatis et levissime curvatis, polis subangustis sed rotundatis, margine ventrali et dorsali valde undulato-noduloso, nodulis dorsalibus iis ventralibus alternantibus; striis validis, 8 in 10 μ; nodulis terminalibus conspicuis; in aspectu cingulato rectangulari, lateribus levissime et latissime biundulatis.

Long. 41–112 μ; lat. 11–12·5 μ; lat. pol. 5–6·5 μ.

Hab. Yan Yean Reservoir, at the weedy margins (Mar. and June, 1905).

This species of *Eunotia* is very characteristic, and I can find no published record of one which agrees with it. The crinkled nature of the valves, with the alternating nodulations of the dorsal and ventral margins, and the comparatively slight curvature, are its distinguishing features. The apices are somewhat narrow, but rounded and exactly equal, and the terminal nodule is ventral and conspicuous. The striations are rather coarse and very distinct. The individuals varied much in length and consequently in the number of nodulations. According to the length there are from 3 to 7 nodulations on the dorsal margin and from 2 to 7 on the ventral margin. In the more elongated individuals both margins possess an equal number of nodulations, but in the shortest forms there are three dorsal and only two ventral nodulations. In the girdle-view the cell is rectangular and the longer margins of the valve are very slightly biundulate.

The nodulation of *Eunotia crispula* reminds one very much of *Actinella mirabilis*, Grun., but the extremities of the valves are not asymmetrical, and the cells are not united to form colonies as in *Actinella* and *Desmagonium*.

E. crispula was also frequent in some collections made by Mr. Hardy at Heidelberg, Victoria (Mar. 1905).

Family **NAVICULACEÆ**.

Genus NAVICULA, *Ehrenb.*

64. Navicula bicapitata, *Lagerstedt, Spitsberg. Diat.* p. 23, t. 1. fig. 5; *Van Heurck, Synops. Diat. Belg.* p. 78, t. 6. fig. 14.

A form identical with *Pinnularia interrupta*, W. Sm. (1853), forma *biceps*, (Greg.) Cleve, Synops. Navic. Diat. ii. (1895) p. 76 (= *N. biceps*, Greg., 1856; *P. interrupta β*, W. Sm. Brit. Diat. ii. p. 96). (Pl. **3**. fig. 13.)

This Diatom occurred in considerable abundance both in the plankton and among the weeds at the lake-margin. The extremities are less capitate than in

Lagerstedt's Spitsbergen specimens of *Navicula bicapitata*, but are distinctly produced and slightly dilated. There is a clear space of considerable width on each side of the raphe, owing to the shortness of the striæ, and in the middle opposite the central nodule this clear area widens still further. The striæ do not cease, however, in the median part of the valve; they strongly converge towards both the central and terminal nodules, and are about 9–10 in 10 μ.

In outline this form agrees fairly closely with *Pinnularia microstauron*, Cleve, Synops. Navic. Diat. ii. 1895, p. 77 (= *N. bicapitata* var. *hybrida*, Grun.; *cf.* Van Heurck, *l. c.* t. 6. fig. 9), but the striæ do not cease in the middle. It is also very near *Navicula subcapitata*, Greg., especially in the less capitate poles, but as the striæ do not stop on each side of the middle, and the poles are distinctly angular, I have regarded it as more nearly approaching *N. bicapitata*. In outline it bears much resemblance to *N. kefvingensis*, Ehrenb., from Jaaling, figured in Schmidt's Atlas Diat. t. 47. fig. 63, but the extremities are not quite so narrowed and the striæ do not reach so close to the raphe.

Perhaps the form seen so abundantly from Australia should be regarded as *Pinnularia microstauron*, (Ehrenb.) Cleve, but it seems almost impossible to demarcate between *P. interrupta*, *P. mesolepta*, *P. microstauron*, *N. bicapitata*, and *N. subcapitata*, as their numerous forms constitute a continuous series. The Australian forms agree more closely with the published figures of *N. bicapitata* than with any other, and I have for the present adopted that name.

Genus GYROSIGMA, *Hass.*

65. GYROSIGMA ELONGATUM, (*W. Sm.*) *nob.*, var. ?

Long. 362 μ; lat. med. 22 μ. (Pl. **3**. fig. 17.)

Hab. Yan Yean Reservoir, very scarce in the plankton (Nov. 1905).

This *Gyrosigma* differs very much from any other species I have observed in fresh water, and I can find no figure exactly corresponding to it in Peragallo's 'Monogr. Gen. *Pleurosigma*,' Le Diatomiste (1890–91). The nearest are "*P. decorum*, W. Sm., var. ? *americanum*, Per." (= *P. longum* Cleve, var. *americanum* (Per.), Cleve), and *P. elongatum*, W. Sm. (*vide* Peragallo, *l. c.* p. 5, t. 1. fig. 9, and p. 7, t. 3. fig. 5). The first of these is perhaps the nearest as regards outline and the position of the raphe, but the striæ are very delicate and oblique as in *P. elongatum*. The extremities of the valves are about as acute as those of *P. elongatum* (especially Peragallo's fig. 8 on t. 3), but the raphe is very decidedly oblique and not central. The Australian plant has also a more elongate median part of the valve, in which the margins are parallel for some distance, and the central nodule is likewise oblong-elliptic.

I have only observed five specimens of this interesting *Gyrosigma*, and if the examination of further individuals indicates that its characters are constant, it would perhaps be better to regard it as a new freshwater species. If Cleve's separation of the genera *Gyrosigma* and *Pleurosigma* be accepted (*cf.* Cleve, Synops. Navic. Diat. i. (1894) pp. 32 and 112), the Australian species would come under the latter genus; if his separation be not accepted, then it is a species of *Gyrosigma*.

Class **PERIDINEÆ.**

Order PERIDINIALES.

Family **PERIDINIACEÆ.**

Genus PERIDINIUM, *Ehrenb.*

66. Peridinium Volzii, *Lemm. in Abh. Nat. Ver. Brem.* xviii. (1904) p. 166, t. 11. figs. 15–18.

Var. australe, var. n. (Text-fig. 10, A–G.)

Var. paullo major: hypovalva cum tabulis antapicalibus duobus *asymmetricis*; tabulis rhomboideis et tabulis apicalibus 4 epivalvæ cum iis formæ typicæ non plane congruentibus; fossa longitudinis ut visa ventrali sine spira minuta terminali.

Long. 40–56 μ; lat. 39–59 μ.

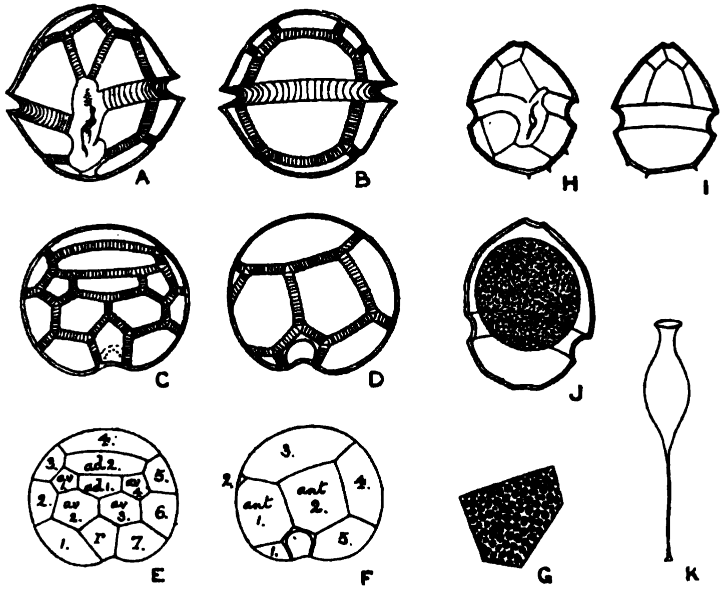
Hab. Yan Yean Reservoir, in the plankton (mostly from Nov. 1905 to Feb. 1906) and at the weedy margins (May and Dec. 1905).

The general disposition of the plates composing the cell-wall is very similar to the arrangement in a species of *Peridinium* recently found at Singapore, and described by Lemmermann as *P. Volzii.* There are, however, certain differences in the shape of the four apical plates and the two dorsal plates, and in the asymmetrical disposition of the two antapical plates, not to mention a few other minor distinctions.

Mr. Lemmermann very kindly examined both specimens and drawings of the Australian form, and as he regards it as somewhat different from the organism he recorded from Singapore, I have described it as a variety of that species.

The most interesting feature exhibited by *P. Volzii* var. *australe* is the asymmetrical disposition of the two antapical plates, as such a character leads one to suspect that the Australian form is one of the connecting links between the two genera *Peridinium* and *Gonyaulax.* In the latter genus the hypovalve possesses one central antapical plate and an occasional plate, and it is quite conceivable that by a further slight rotation of the two antapical plates of *P. Volzii* var. *australe,* until one of them attained a central position, a condition corresponding to that which obtains in *Gonyaulax* may easily have been produced. It is therefore quite possible that the genus *Gonyaulax* *,

Fig. 10.



A–G. *Peridinium Volzii*, Lemm., var. *australe*, var. n. A, ventral view; B, dorsal view; C, epivalve; D, hypovalve. E, outline of epivalve with the various plates named:—1–7, præ-equatorial plates; *ad.* 1 and *ad.* 2, dorsal apical plates; *av.* 1–*av.* 4, ventral apical plates; *r*, rhomboidal plate. F, outline of hypovalve to show plates:—1–5, post-equatorial plates; *ant.* 1 and *ant.* 2, obliquely disposed antapical plates. A–F, × 500. G, single plate to show areolations, × 1000.

H–J. *Peridinium inconspicuum*, Lemm., × 1000. J, old cell-wall containing a cyst.

K. *Dinobryon elegantissimum*, sp. n., × 500.

the species of which are neither so numerous nor so widely distributed as those of *Peridinium*, has had a direct origin from the latter genus.

67. Peridinium inconspicuum, *Lemm. in Abh. Nat. Ver. Bremen*, xvi. (1902) p. 350; *in Engler, Bot. Jahrb.* xxxiv. (1905) t. 8. fig. 1.

Long. 17–18 μ; lat. 13·5–15 μ; diam. cyst. 13·5–15·5 μ. (Text-fig. 10, H–J.)

Hab. Yan Yean Reservoir, at the weedy margins (Nov. 1905–Jan. 1906).

This minute species was very abundant in December 1905, in which month a few resting cysts were formed. These were ovoid-globose, with smooth walls, and a little smaller than the somewhat distended wall of the mother-cell.

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* The genus *Gonyaulax* has been recently revised by Lemmermann in Botan. Centralbl. xxi. (1907) pp. 296–300.

Class **FLAGELLATA.**

Family **DINOBRYACEÆ.**

Genus DINOBRYON, *Ehrenb.*

68. DINOBRYON ELEGANTISSIMUM, sp. n. (Text-fig. 10, K.)

Membrana evacuata firma et hyalina; parte mediana ellipsoidea, parte superiore producta et angustiore, colliformi cum osculo expanso ad apicem, parte inferiore acute conica et in stipitem tenuem elongatum producta, cum basin stipitis expansa.

Long. (sine stip.) 34 μ; long. stip. 28 μ; lat. max. 13 μ; lat. coll. 4 μ; lat. oscul. 7·5 μ.

Hab. Yan Yean Reservoir, at the weedy margin (Jan. 1906); very rare.

Only two empty tests of this species were observed. It is distinguished by its elegance of outline, by its rather narrow neck with an expanded mouth, and by its elongated stalk. The stalk possesses a slight basal disc for attachment, from which one would conclude that the individuals are solitary. In the two specimens seen no traces of the cell-contents were present, and for this reason I am rather doubtful about the correct inclusion of this organism in the genus *Dinobryon.*

VI. THE PECULIARITIES OF THE AUSTRALASIAN ALGA-FLORA.

As I have previously pointed out*, no group of the freshwater Algæ exhibits such marked geographical peculiarities as the Desmidiaceæ. Some of the subaerial Algæ, such as many species of *Trentepohlia*, *Cephaleuros*, *Phyllosiphon*, of the Scytonemaceæ, Nostocaceæ, etc., are restricted to certain regions, but, apart from indefinite limitations to tropical or temperate zones, their distribution is rather a question of atmospheric conditions than of geographical situation. Most of the Oedogoniaceæ, Ulotrichaceæ, Cladophoraceæ, Zygnemaceæ, and Protococcaceæ are more or less world-wide as either temperate or tropical species, or as both; and there is no reason to suppose that the new species of these groups described in the present paper (*Ulothrix idiospora*, *Debarya Hardyi*, *Mougeotia victoriensis*, etc.) are restricted to Australia. It is more than probable that they will be found in New Zealand, in various islands of the Pacific, in the East Indian Archipelago, and parts of Eastern Asia, and not unlikely in Central and South Africa and South America.

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* G. S. West in Journ. Linn. Soc., Bot. xxxviii. (1907) p. 82; W. & G. S. West in Ann. Roy. Bot. Gard. Calcutta, vol. vi. (1907) p. 176.

The Yan Yean collections were fairly rich in the Desmidiaceæ, and it is this group which must be examined for the peculiarities which enable one to recognise from what part of the world the collections were obtained without having previously been informed. Even with our present imperfect knowledge, one can almost invariably do this with a rich Desmid collection. On contrasting Nordstedt's valuable contribution to the freshwater Algæ of New Zealand * with the present paper, it is at once obvious that Australia and New Zealand have much in common amongst the Desmids, including many species which are only known to occur in this region. In the Yan Yean collections the Australasian types were the following:—

Pleurotænium mamillatum, G. S. West.
Micrasterias Hardyi, G. S. West.
Cosmarium Capitulum, Roy & Biss., var. *australe*, G. S. West.
„ *perfissum*, G. S. West.
„ *achondroides*, G. S. West.
„ *dorsitruncatum*, (Nordst.) G. S. West.
„ *Murrayi*, Playfair.
„ *turgidum*, Bréb., var. *ovatum*, Nordst.
„ *amplum*, Nordst.
„ *Hardyi*, G. S. West.
„ *amœnum*, Bréb., var. *mediolæve*, Nordst.
Staurastrum assurgens, Nordst.
„ *sagittarium*, Nordst.
„ *victoriense*, G. S. West.
„ *digitatum*, G. S. West.
„ *sexangulare*, (Buln.) Rabenh., var. *productum*, Nordst.

The following species, although not observed in the Yan Yean drainage area, are also Australasian types so far as can be judged from our present knowledge:—

Euastrum multigibberum, Nordst.
Micrasterias suboblonga, Nordst.
Cosmarium securiforme, Borge.
Xanthidium bifurcum, Borge.
„ *gloriosum*, G. S. West (=*X. pulcherrimum*, Playfair).
„ *multicorne*, Borge.
Staurastrum cruciforme, Playfair.
„ *elegans*, Borge.
Hyalotheca hians, Nordst.

The Australian Desmid-flora is a rich one, probably far richer than that of

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* O. Nordstedt in Kongl. Sv. Vet.-Akad. Handl. xxii. no. 8 (1888).

Europe, and even as far south as Victoria it is largely tropical in character. It includes a number of species which are general in the Indo-Malayan region, amongst which may be mentioned:—*Pleurotænium Kayei*, (Arch.) Rabenh.; *Triploceras gracile*, Bail., and varieties*; *Euastrum longicolle*, Nordst.; *E. rostratum*, Ralfs, var. *præmorsum*, Nordst.; *Micrasterias Möbii*, W. & G. S. West; *Cosmarium Askenasyi*, Schmidle; *C. tjibenongense*, Gutw.; *Staurastrum unicorne*, W. B. Turn., and varieties; *S. patens*, W. B. Turn., and varieties; and *S. indentatum*, W. & G. S. West. It appears as though the Australian Desmid-flora had a good sprinkling of tropical Indo-Malayan species, even such a common tropical species as *Staurastrum unicorne* in the Indian region extending as far south as Victoria.

A few African and Malagasy species occur, such as forms of *Cosmarium subtriordinatum*, W. & G. S. West; *Staurastrum excavatum*, W. & G. S. West; *S. bibrachiatum*, Reinsch, var. *cymatium*, W. & G. S. West †.

A few South American (Brazilian) species likewise exist in Australia, and others which are more closely allied to South American species than any other known forms. *Pleurotænium ovatum*, *Staurastrum leptacanthum*, *S. zonatum*, and *S. leptocladum* were originally described from Brazil, and *Staurastrum victoriense* is more nearly allied to the Brazilian *S. nudibrachiatum* than to any other known species.

VII. GENERAL SUMMARY.

1. *The* PHYTOPLANKTON *of the Yan Yean Reservoir, Victoria, is rich both in number of species and individuals. It reaches its greatest development in March and April,* although the greatest bulk of the plankton as a whole is in July, August, and September, when the Crustacea are dominant. *The phytoplankton is poorest in September and October,* in which months it is almost absent.

It does not contain many Flagellates, and remarkably few Myxophyceæ. The absence of the Blue-green element at all times of the year is one of its most noteworthy features.

The complete absence of *Ceratium Hirundinella* is also surprising, especially as this organism occurs in the plankton of the Toorourong Reservoir which supplies the greater part of the water to the Yan Yean.

It has a rich Desmid-flora, containing many characteristic Australasian types. The plankton for a great part of the year can be described as a "Desmid-plankton," and from February to April (or even May) it consists almost exclusively of these interesting and elegant Conjugates. In the richness of its Desmid-flora it compares very well with the lakes of the western British lake-areas. *The Yan Yean Reservoir furnishes another instance of a rich Desmid-plankton occurring in a lake situated on the Older Palæozoic formations and receiving the drainage from extensive outcrops of these old rocks.* A portion of the drainage, as is so often the case in mountainous, Older Palæozoic areas, is also derived from outcrops of igneous material.

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* *Triploceras gracile* exhibits more variation and abnormalities in the Australasian region than in any other part of the world.

† Bohlin has also recorded this species from the Azores.

In the complete absence of *Fragilaria* and *Asterionella*, and of the star-dispositions of the frustules of *Tabellaria*, the phytoplankton differs conspicuously from the European plankton, but agrees with the known plankton of the great African lakes.

In the plankton of the Yan Yean Reservoir there are three distinct phases :—

I. *Nov.–Jan.* (beginning of warm period).—*Melosira granulata* and *Dinobryon* are the chief constituents, together with a few of the Protococcoideæ (such as *Pediastrum duplex* var. *clathratum* and *Eudorina elegans*).

II. *Feb.–May* (warm period or summer phase).—Desmids dominant, with a little *Melosira granulata*.

III. *June–Oct.* (cold period).—Crustacea dominant; phytoplankton almost absent.

The summer phase of the plankton (from Feb. to May), which in most European and North American lakes is dominated by Blue-green Algæ, is here dominated by Desmids (as in many lakes of the British area) and by *Melosira granulata*. The latter is an exception to most of the freshwater Bacillarieæ in having its maximum in the warmest period of the year.

Out of 104 species and 16 varieties observed in the phytoplankton, 23 species and 5 varieties were exclusively confined to it, not having been seen from any other part of the entire drainage area.

2. The MICROPHYTIC BENTHOS or littoral Alga-flora of the Yan Yean Reservoir was richer in species than the phytoplankton and contained many interesting types. *Many species common to the plankton and the benthos attain first a maximum in the plankton and subsequently a maximum in the benthos*, the time which elapses between these two maxima varying from three to eight weeks.

There are three phases in the benthos during the year, but these are not so marked as the phases of the phytoplankton. They may be stated as follows :—

I. *Nov.–Jan.* (vernal rise of temperature).—Dominance of Oedogoniaceæ and Zygnemaceæ (mostly in the fruiting condition). Many Desmids present, and some species abundant. *Peridinium* and *Dinobryon* frequent.

II. *Feb.–July* (warm period or summer phase).—Desmids dominant. *Melosira granulata* and *Cocconeis Placentula* conspicuous.

III. *Sept.–Oct.* (cold period).—Very little Algal life, at any rate in the active vegetative condition. *Tabellaria flocculosa* and *Vanheurckia viridula* both noticeable.

3. Some light is thrown on the ORIGIN OF THE MICROPHYTIC BENTHOS AND OF THE PHYTOPLANKTON by the investigations carried out in other parts of the drainage area. *The upper dams* (Toorourong Reservoir, Wallaby Creek Weir, and Silver Creek Weir) *yield few plankton species* owing to the disturbed state of the water, but *their examination indicates that the Yan Yean Reservoir does not derive its numerous Algal constituents from these dams although receiving six-sevenths of its water-supply from them. The rich Alga-flora of the Yan Yean appears to be derived almost entirely from its own small catchment basin,* and along the two marshy inlets of Rana Creek and Ottelia Creek.

The phytoplankton is partially recruited from the microphytic benthos, and it also consists in part of well-established forms which are not recruited from the shore-regions. Some of these well-established plankton forms seemingly supply the benthos with recruits in greater or smaller numbers during the autumnal fall of temperature.

Some of the plankton species are not derived from the benthos, and neither do they appear to be acquired by the aqueduct which brings the chief water-supply from the large drainage area. As these species are in some cases dominant forms, they must have been established in the plankton for some time. Their actual origin is mostly a matter for future investigation.

4. *Over* 300 *species of Algæ were observed* in the complete collections *from the entire Yan Yean drainage area.* Of these, 14 *species and* 11 *varieties are here described for the first time,* and 4 species and 5 varieties which had previously been only partially described are here dealt with in greater detail, and for the first time figured.

University Botanical Laboratory, Birmingham,
April 1908.

EXPLANATION OF THE PLATES.

PLATE 1.

Photomicrographs of plankton from the Yan Yean Reservoir. Two upper photographs January and March; two lower photographs April. All × 100.

Figs. 1 & 2. *Pediastrum duplex* var. *reticulatum*; 3. *Scenedesmus bijugatus* forma *arcuata*; 4 & 5. *Melosira granulata*; 6. *Tabellaria flocculosa*; 7 & 8. *Dinobryon cylindricum* var. *divergens*; 9. *D. elongatum* var. *undulatum*.

10. *Micrasterias Hardyi*; 11. *Staurastrum leptacanthum*; 12 & 13. *S. corniculatum*;

14 & 15. *S. corniculatum* var. *spinigerum*; 16 & 17. *S. mucronatum* var. *delicatulum*; 18. *S. sexangulare*; 19. *Melosira granulata*; 20. *Cosmarium pseudoprotuberans* var. *angustius*; 21. *Closteriopsis longissima*.

Figs. 22 & 23. *Micrasterias Hardyi*; 24. *Staurastrum assurgens* var. *victoriense*; 25. *S. leptacanthum*; 26. *S. dejectum*; 27. *Cosmarium pseudoprotuberans* var. *angustius*; 28. *C. Capitulum* var. *australe*; 29. *Ankistrodesmus falcatus*; 30. *Melosira granulata*.

31 & 32. *Micrasterias Hardyi*; 33. Damaged semicell of *Cosmarium achondroides*: 34. *C. Hardyi*; 35. *C. Capitulum* var. *australe*; 36 & 37. *C. tortum* forma *trigona*; 38. *Staurastrum corniculatum*; 39. *S. assurgens* var. *victoriense*; 40. *S. paradoxum* var. *longipes*; 41. *S. cuspidatum*: 42. Old carapace of *Bosmina*, with quantities of decaying organic matter attached.

Note.—The dark, ill-defined patches in the March and April plankton consist of irregular masses of decaying organic matter.

Plate 2.

Fig. 1. *Mougeotia victoriensis*, sp. n. × 500. Conjugating filaments showing two spores each surrounded by a wide mucous coat to which are attached numerous small particles of mineral matter.

Figs. 2–3. *Zygnema spontaneum*, Nordst. × 500. In fig. 3 one zygospore (*z*) is shown and two aplanospores (*apl.*).

4–5. *Mougeotia subcrassa*, sp. n. 4, × 200; 5, spore with portions of walls of attached cells, × 500.

6–11. *Debarya Hardyi*, sp. n. 6, × 500; early stage of conjugation, just after formation of conjugating-tube; 7–9, × 1000, extremities of emptying gametangia to show the internal thickening which is gradually laid down until they become solid. 10 & 11, two adult zygospores, × 500.

12–14. *Ulothrix idiospora*, sp. n. 12 & 13, two filaments showing vegetative cells and adult akinetes (*apl.*), 500. × *chl.*, chloroplast; *py.*, pyrenoid. 14, akinete to show scrobiculation of wall, × 1000.

15. *Ceratium Hirundinella*, O. F. Müll. × 200. A form from the plankton of the Toorourong Reservoir showing an inward curvature of the third antapical horn (*a*).

Plate 3.

Figs. 1–2. *Pleurotænium mamillatum*, G. S. West. 1, × 520; 2, × 430.

3. *Sphærozosma Wallichii*, Jacobs., forma *australis*. × 840.

4–5. *Triploceras gracile*, Bail., var. *robustum*, var. n. × 500. 5, side view of another apex.

6–7. *Triploceras gracile*, Bail., var. *aculeatum*, Nordst., forma. × 500. 7, side view of apical region.

8–10. *Triploceras gracile*, Bail., var. *denticulatum*, (Playfair) nob. × 500. Fig. 9 shows side view of apical region.

11. *Staurastrum unicorne*, W. B. Turn., var. *nodiferum*, (W. B. Turn.) W. & G. S. West. A form, × 840.

12. *Staurastrum neglectum*, sp. n. *a* and *b*, × 500; *b′*, × 840.

13. *Navicula bicapitata*, Lagerstedt. × 840.

14. *Eunotia crispula*, sp. n. × 500.

15–16. *Rhizosolenia morsa*, W. & G. S. West. × 840.

17. *Gyrosigma elongatum*, (W. Sm.) nob., var.? × 500.

PLATE 4.

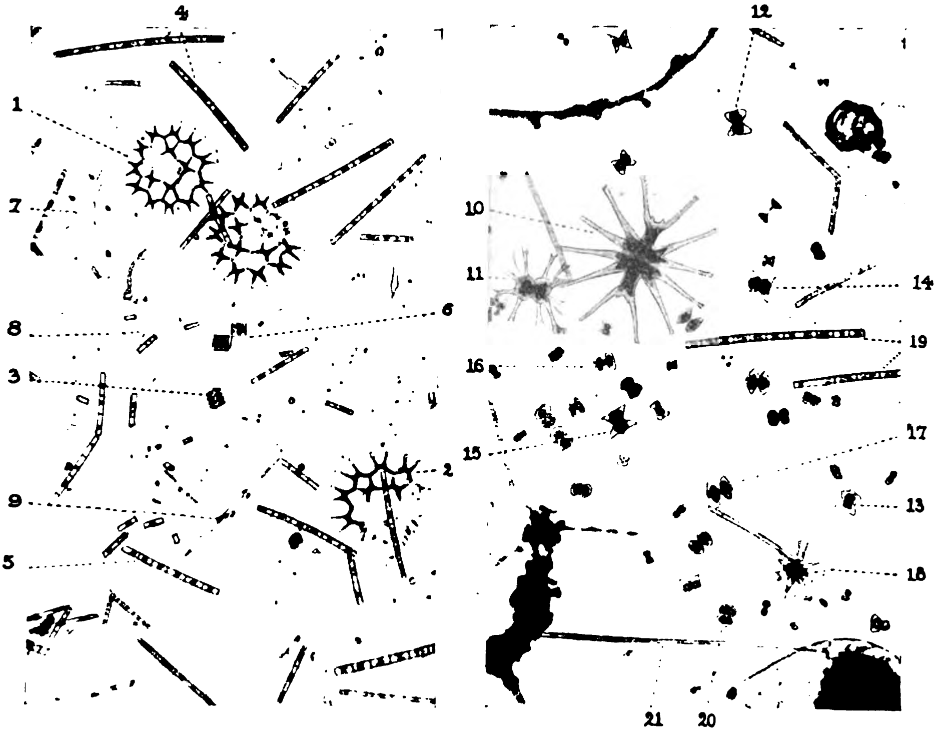
Fig. 1. *Micrasterias Thomasiana*, Arch., var. *pulcherrima*, var. n. × 350.
2. *Cosmarium perfissum*, sp. n. *a* and *b*, × 500; *a'*, × 840.
3. ,, *tjibenongense*, Gutw., forma. × 500.
4. ,, *dorsitruncatum*, (Nordst.) nob. 500.
5. ,, *Murrayi*, Playfair. *a*, × 1000; *b* and *c*, × 840.
6. ,, *subtriordinatum*, W. & G. S. West, forma. × 840.
7. ,, *Phaseolus*, Bréb., forma. × 500.
8. ,, *Hardyi*, G. S. West. × 430.
9-10. ,, *achondroides*, sp. n. × 500.
11. ,, *trachypleurum*, Lund., var. *subglabrum*, var. n. × 500.
12. ,, *quadratulum*, (Gay) De Toni. × 1000.

PLATE 5.

Figs. 1-2. *Micrasterias Hardyi*, G. S. West. × 500. 2, basal view of semicell.
3-4. *Cosmarium tortum*, Lagerh. & Nordst., forma *trigona*, G. S. West. × 430.
5. *Staurastrum mucronatum*, Ralfs, var. *delicatulum*, G. S. West. × 430.
6. *Cosmarium Capitulum*, Roy & Biss., var. *australe*, G. S. West. *a*, × 520; *a'* and *b*, × 430.
7. *Cosmarium affine*, Racib., var. *excavatum*, var. n. × 840.
8. *Staurastrum muticum*, Bréb., var. *victoriense*, G. S. West. × 430.
9. *Cosmarium goniodes*, W. & G. S. West, var. *subturgidum*, W. & G. S. West. × 840.
10. *Staurastrum lævispinum*, Biss., var. *subbrachiatum*, G. S. West. × 430.
11-12. *Staurastrum digitatum*, sp. n. × 500. 11, four-rayed specimen; 12, five-rayed specimen.
13-15. *Staurastrum victoriense*, sp. n. × 500.
16. *Cosmarium moniliforme*, (Turp.) Ralfs, var. *limneticum*, W. & G. S. West. × 500.

PLATE 6.

Figs. 1-3. *Radiofilum conjunctivum*, Schmidle. × 1000. Fig. 2 is the apex of a filament to show the rounded apical cell. Fig. 3 shows a curious branched condition. *chl.*, parietal, cup-shaped chloroplast.
4-8. *Lagerheimia splendens*, sp. n. 4-6, × 500; 7 & 8, × 840. Figs. 5 & 8 show the parietal chloroplast (*chl.*).
9. Zygospore of *Pleurotænium ovatum*, Nordst., var. *tumidum*, Mask. × 220. The inner and middle coats have shrunk away from the outer coat, and the middle coat is externally papillate.
10-12. *Staurastrum striolatum*, (Näg.) Arch. 10 & 11, × 550; 12, × 500. Fig. 10, front view of zygospore with attached semicells; fig. 11, zygospore seen from the side; fig. 12, empty vegetative cell.
13. *Staurastrum senarium*, (Ehrenb.) Ralfs. × 500.
14. ,, *patens*, W. B. Turn., var. *planctonicum*, G. S. West. × 520.
15-16. ,, *bibrachiatum*, Reinsch, var. *cymatium*. W. & G. S. West. × 500. Fig. 15 shows an abnormal lower semicell almost identical in character with a semicell of *S. tetracerum*, Ralfs.
17. *Staurastrum assurgens*, Nordst., var. *victoriense*, var. n. × 430.
18. Very large form of preceding variety, × 500.
19-20. *Staurastrum excavatum*, W. & G. S. West, forma. × 500.
21-22. ,, *Hardyi*, sp. n. 21, × 840; 22, × 650.
23. ,, *longiradiatum*, W. & G. S. West, var. *subnudum*, var. n. × 500.



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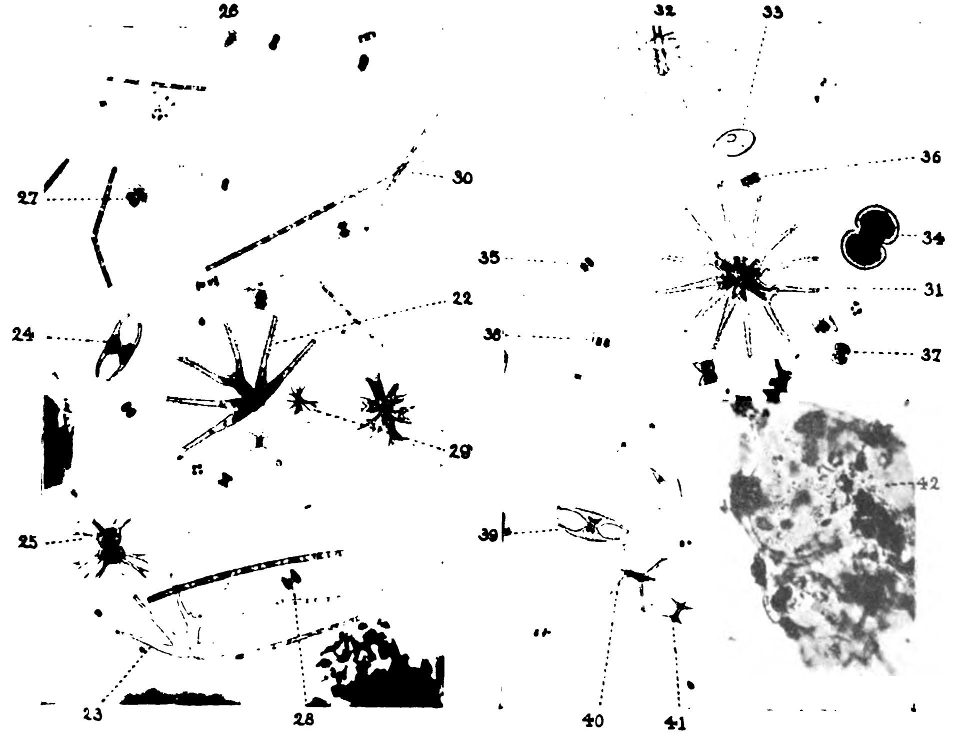

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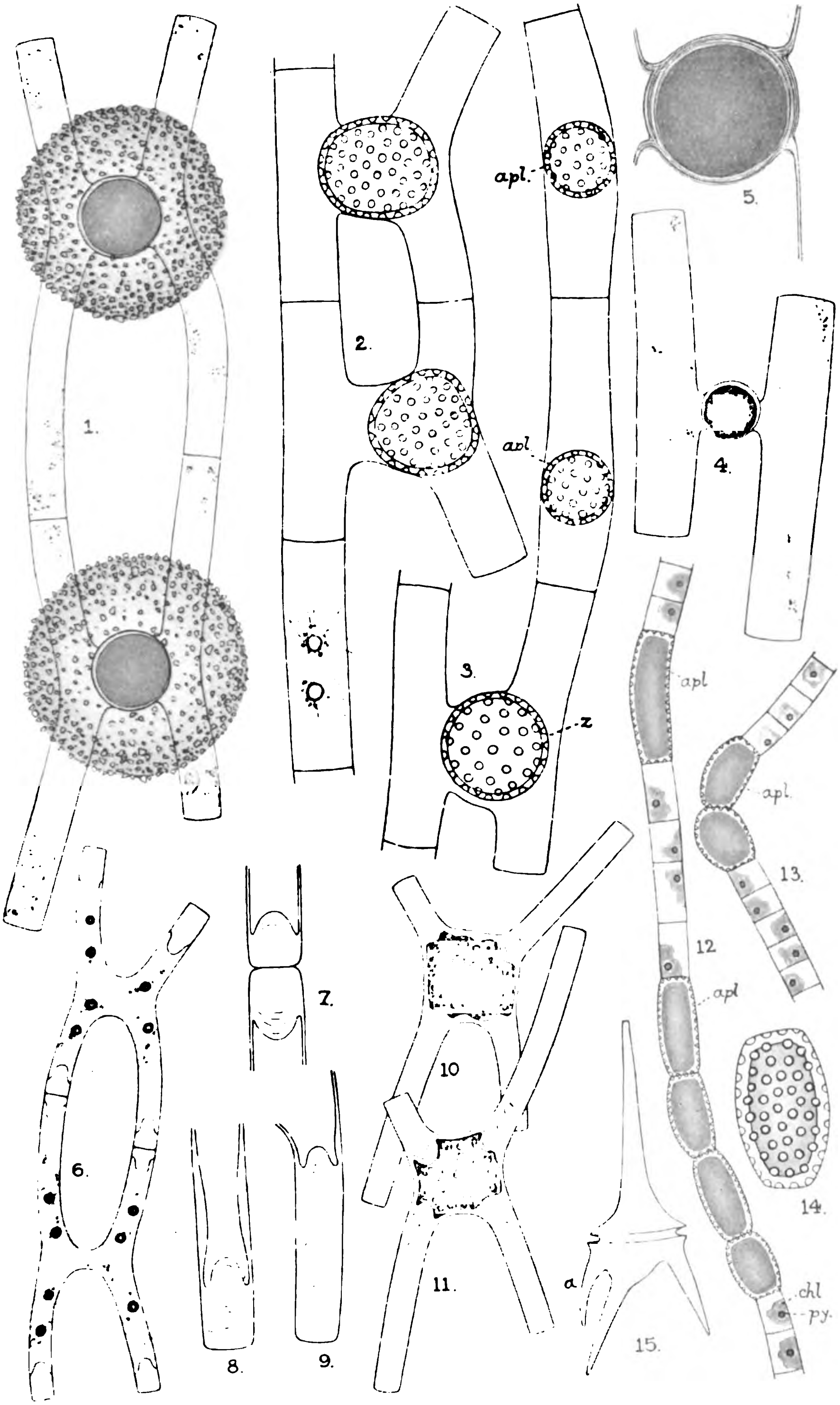
APRIL.

G.S.West photomicrogr.

AUSTRALIAN PLANKTON.



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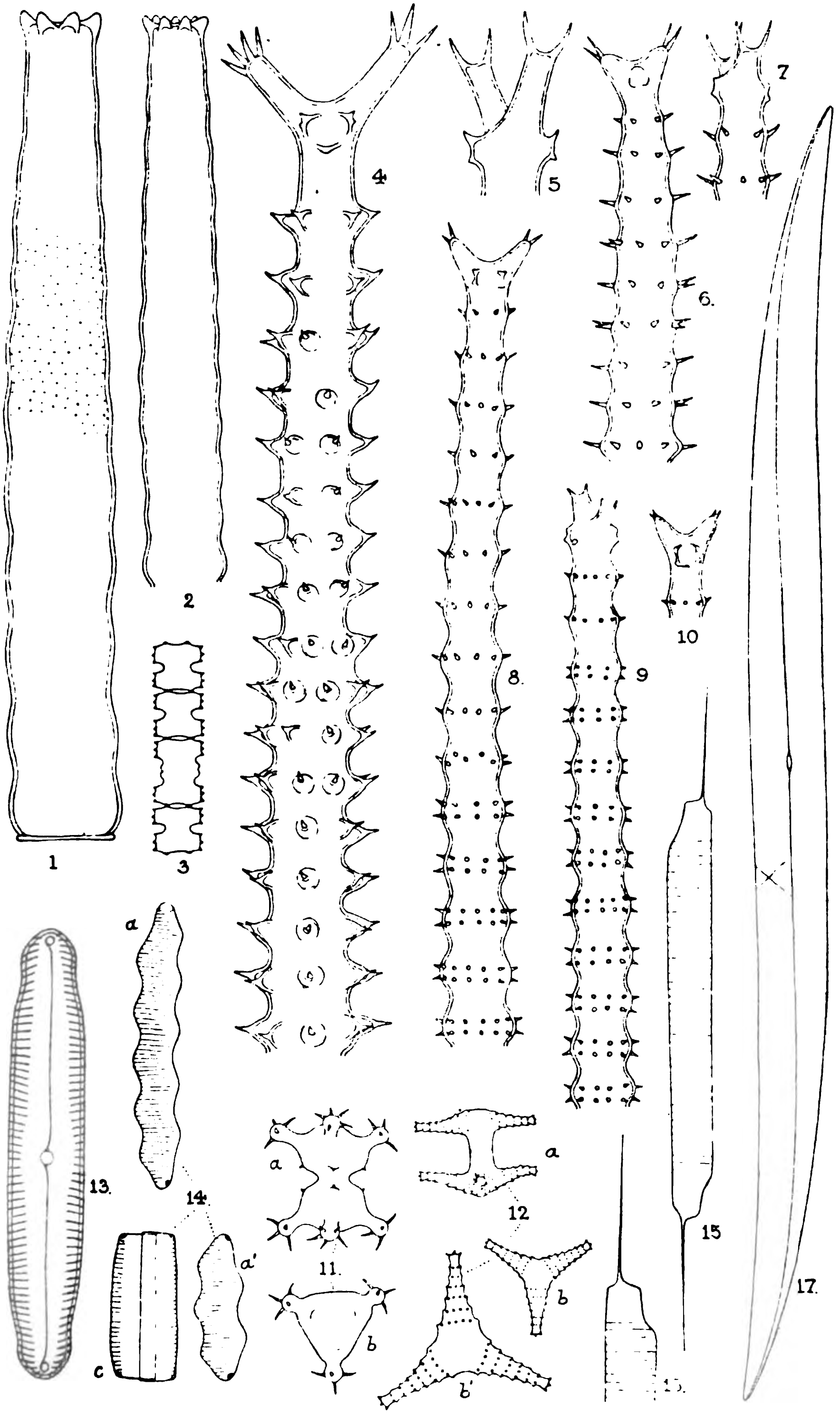
AUSTRALIAN ALGÆ.



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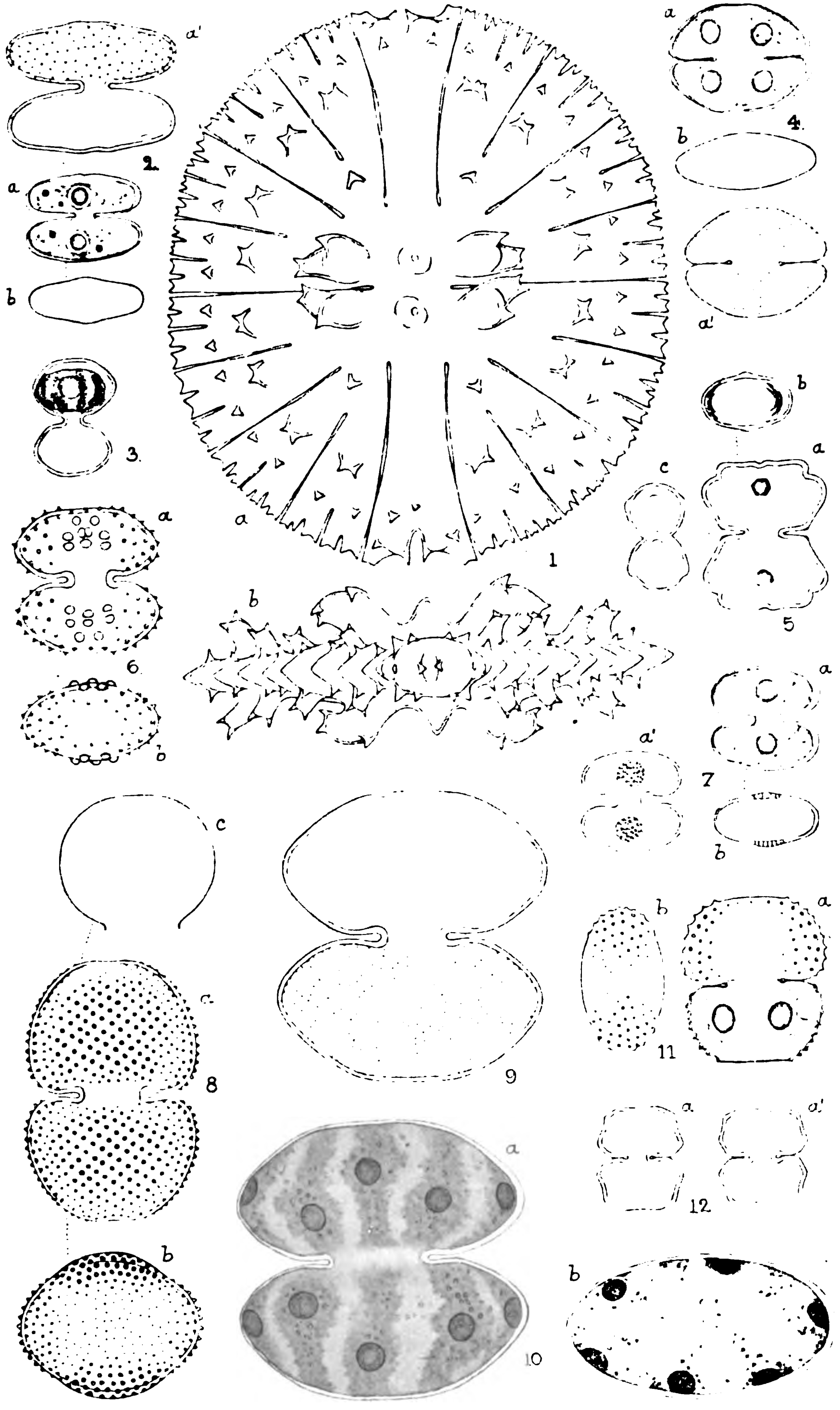

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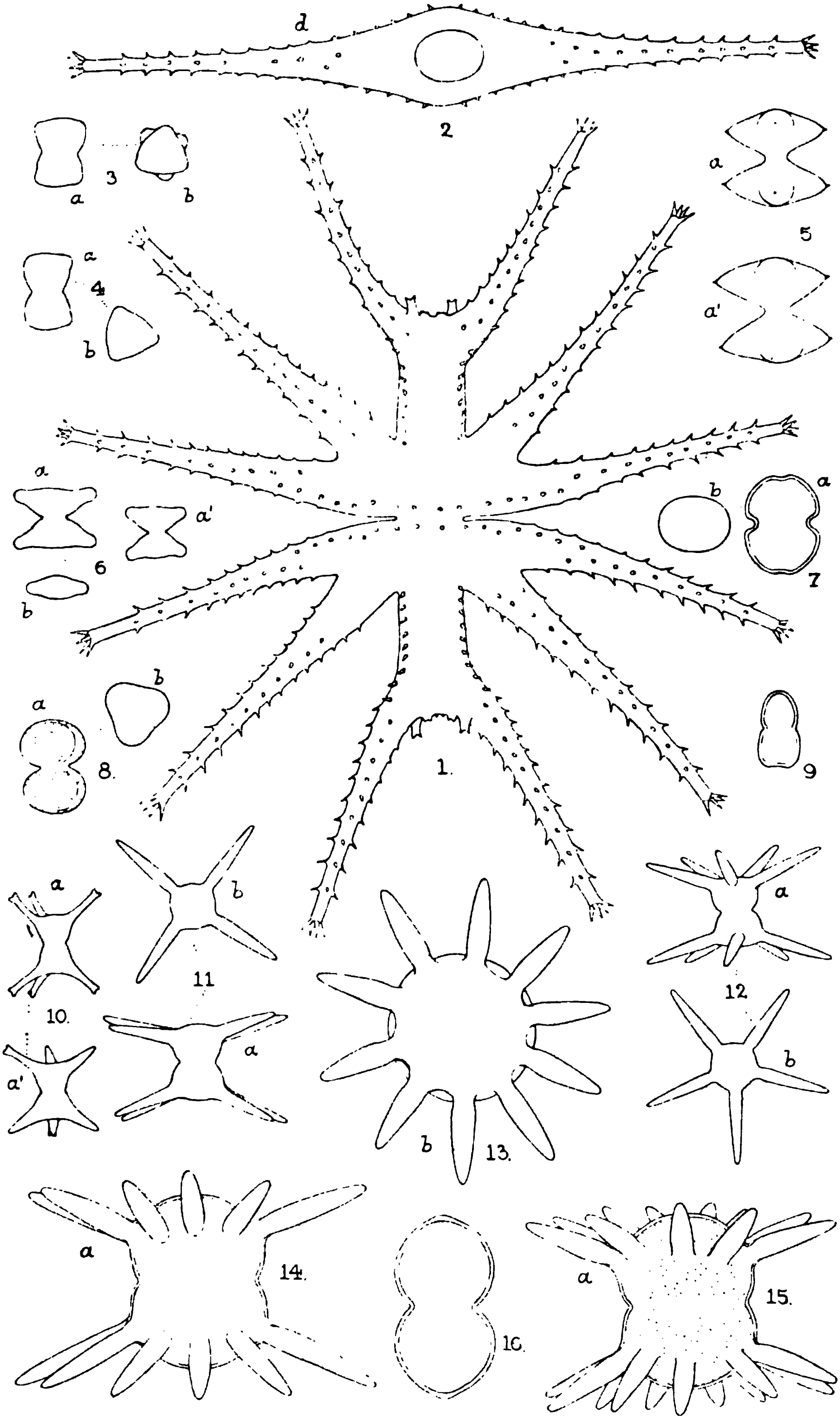

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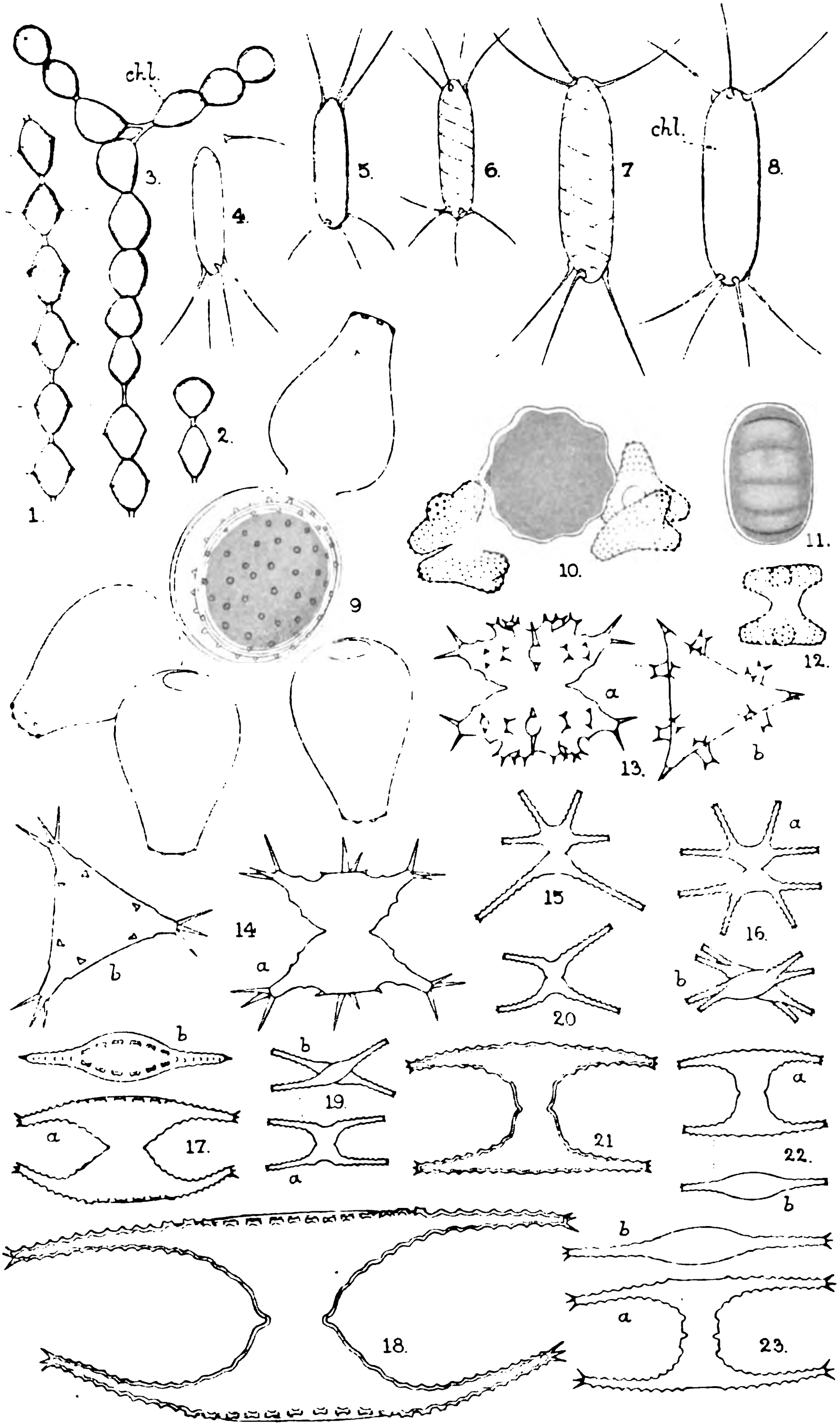

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AUSTRALIAN ALGÆ.

West,
1909.

⑤

A BIOLOGICAL INVESTIGATION OF THE PERIDINIEÆ OF SUTTON PARK, WARWICKSHIRE

By G. S. West.

[*Re-printed from* The New Phytologist, *Vol. VIII., Nos. 5 & 6,*
May and June, 1909].

A BIOLOGICAL INVESTIGATION OF THE PERIDINIEÆ OF SUTTON PARK, WARWICKSHIRE.

BY G. S. WEST, M.A., D.Sc., F.L.S.

[TEXT-FIGS. 20—26].

[*Re-printed from* THE NEW PHYTOLOGIST, *Vol. VIII., No. 5 & 6, May and June, 1909.*]

LITTLE is known of the Peridinieæ of the midlands of England, or indeed, of any of the low-lying parts of the country, although those of mountainous areas have been to some extent investigated. I have been engaged since October, 1906, in making a more or less continuous series of observations on the general periodicity and life-histories of the Algæ which occur in that fine stretch of primitive country to the north-east of Birmingham known as Sutton Park. Some of these observations have now proceeded far enough to render publication of certain facts advisable, and the present account of Peridinieæ is sufficient to show that there are probably many interesting freshwater members of this group in the less elevated areas of the British Islands.

The species of *Peridinium* which is generally recorded as common in the ponds and pools of flat countries is *P. tabulatum* (Ehrenb.) Clap. et Lachm., but I have found no trace of this organism in either Warwickshire or Worcestershire.

In all, seven species of the Peridinieæ have been observed in the pools and bogs of Sutton Park. Only one of these—*Glenodinium uliginosum*—is a bog species, occurring among submerged *Sphagnum*, the other six having been found exclusively in the helioplankton of Bracebridge Pool, a sheet of water of rather more than sixteen acres. Three of these, *Peridinium aciculiferum*, *P. anglicum*, and *P. cinctum.* var. *Lemmermanni*, are among the dominating constituents of the plankton of this pool at certain seasons of the year, although I have found no trace of any of them among the weeds at the margins.

I.—GLENODINIUM ULIGINOSUM, Schilling.

Although up to the present unrecorded for the British Islands, this organism is probably more generally distributed in British freshwaters than any other member of the Peridinieæ. It is of very rare occurrence in the waters of pools and lakes, but may often be found in great abundance in bogs and boggy ditches, even up to an altitude of over 2,000 feet.

The active individual has a firm, strong wall, and is generally so packed with a dark black-brown pigment that little can be seen of its internal structure. It swims with the characteristic Peridinian revolving movement, combined with a fairly rapid forward progression. The wall gives only a partial cellulose reaction, and is almost stuctureless, although I have imagined at times I detected a faint indication of a system of component plates.[1]

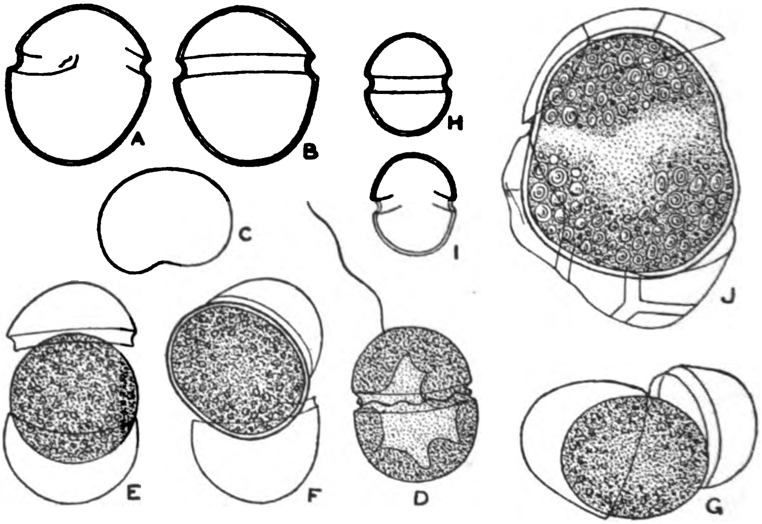

Fig. 20 A—G, *Glenodinium uliginosum*, Schilling. A and B, empty wall showing equatorial groove; C, anterior view showing shallow longitudinal groove; D, young individual developed from a cyst; E, F and G, cyst-formation. H and I, *Glenodinium pulvisculus* (Ehrenb.) Stein. Dorsal and ventral view of empty wall. J, Resting-cyst of *Peridinium cinctum* var *Lemmermanni*. All × 500.

The extent of the equatorial groove is well seen in the empty cell (Fig. 20 A and B), and the less conspicuous longitudinal furrow is fully apparent in a true anterior or posterior view (Fig. 20 C). The evident inequality of the anterior and posterior halves of the cell, the absence of the turgid rims of the equatorial groove, and the complete absence of a red pigment-spot, are characters which appear to clearly mark off this species from *Glenodinium cinctum* (Müll.) Ehrenb.

Glenodinium uliginosum was first noticed in Sutton Park in the autumn of 1906, occurring in large numbers in a boggy ditch among submerged plants of *Sphagnum cymbifolium*, *S. recurvum*, and a long-leaved variety of *Hypnum fluitans*. It occurs in almost all the boggy parts of the Park, among submerged *Sphagnum*, but nowhere in such abundance as in this one ditch. The ditch was easy of access, and I thought it would afford an excellent opportunity for acquiring some information concerning the formation of resting-cysts in this species. Indiscriminate observations in various parts of the British Islands had led me to believe that the formation of cysts in *Glenodinium uliginosum* took place at almost any period of the year, and how far this belief was wrong will be seen from the following observations.

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[1] Schilling also remarks that in one instance he observed a "Täfelung der Hülle." cf. Schilling, "Die Süsswasser-Peridineen," in Flora, 1891, p. 64.

Periodic collections have been made continuously for over two years from precisely the same spot in this boggy ditch, a spot easily marked owing to the proximity of some wooden railings. These collections were commenced in October, 1906, in which month the *Glenodinium* was fairly abundant. Throughout November and December there was a falling off in numbers accompanied by the formation of numerous cysts. Cyst-formation commenced early in November, and by the third week in December the organism had completely encysted. From January (1907) to March, the number of motile individuals gradually increased, reaching a maximum towards the end of the latter month. From the end of March, through April, to the middle of May, there was a reduction in numbers, but from this period there was again a rapid rise to a great maximum in June. In July there was a second minimum, followed again by a third maximum in August. From the middle of August there was a gradual decrease in numbers until by the middle of December the organism had once more completely encysted. The observations were continued through 1908, and show a very similar sequence of three maxima and three minima in the yearly cycle of the organism.

The first maximum is in March, the second in May or June, and the third is during August and the beginning of September. The first minimum occurs in April or May, and the second in July. Only partial encystment occurs, however, and motile individuals can always be found during these first and second minima. The third minimum occurred in the December of three consecutive years, complete encystment taking place, so that for a short period no motile individuals could be found.

The relative abundance of the organism at different seasons of the year has been plotted out on the accompanying chart (Fig. 21), along with a curve of water-temperatures. The temperature of the submerged *Sphagnum* among which the *Glenodinium* occurred, was carefully registered on every occasion on which collections were made. It will be seen from this comparison that there is a marked relationship between the activity of the organism and the temperature

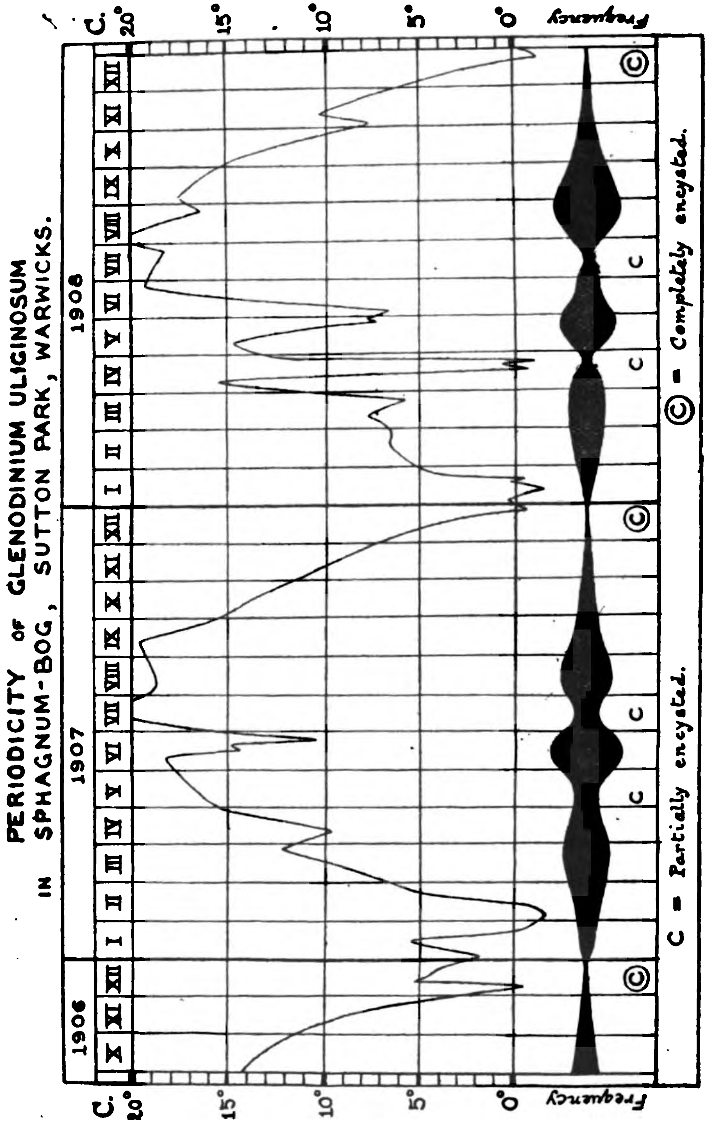

Fig. 21. The upper curve represents the water-temperatures from October, 1906 to December, 1908. The lower black line represents by its varying width the relative abundance of *Glenodinium uliginosum* at different seasons of the year.

of the water. A rapid fall of temperature, especially if prolonged over several months, invariably causes a formation of cysts. The gradual diminution in the activity of the organism leading to a state of complete encystment in December, coincides with the continuous and prolonged autumnal fall of temperature and the cold period immediately following. The July minimum, accompanied by partial encystment, occurred both in 1907 and 1908 at the period of highest temperature. In 1907 the spring minimum occurred in May, seemingly as a result of a rather rapid rise of temperature, whereas the minimum in April, 1908, was without doubt, due to the cold wintry weather which occurred towards the end of that month.

Thus, *Glenodinium uliginosum*, in the habitat examined, becomes completely encysted for a brief period in December after the autumnal fall of temperature, and much reduced in activity (with partial encystment) in July, at the period of highest water-temperature (18-22°C). Other diminutions in activity, such as those observed in the spring months of 1907 and 1908, may occur either as the result of a sudden cold snap, or of a pronounced rise in the temperature. The organism exhibits its greatest activity when the temperature of the water is between 12° and 17°C, and the optimum temperature lies about 15° or 16°C.

The method of encystment is very simple. The old cell-wall is thrown off in two pieces, which often hang together for some time, and the protoplast rounds itself off (Fig. 20 E—G) The cysts are either globular or broadly ellipsoid, and the newly-formed wall varies much in thickness.

I have not been able to satisfy myself that the chromatophores are small and numerous as described by Schilling.[1] It seems probable that one may get a false impression of numerous chromatophores, owing to the repeated lobulation of a much fewer number of larger ones.[2] Also, it can be frequently observed in the young individual developed from the cyst (Fig. 20 D), that there are only two or three lobed parietal chromatophores.

The dimensions of the Sutton Park specimens were as follows:—length of cell 36-43μ; breadth 34-38μ; max. thickness 26-27μ; diam. of cysts 33-40μ.

II.—GLENODINIUM PULVISCULUS (Ehrenb.) Stein.

This species occurred very sparingly in the plankton of Bracebridge Pool during August, 1908. No cysts were observed. It is the smallest species of the genus, the cells having a length of 26—27μ and a breadth of 22μ (Fig. 20, H and I.) The examples agreed well with both Stein's and Schilling's account of the species, and also with specimens which occurred abundantly in the plankton of Tanganyika and Lake Nyasa.

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[1] Schilling, l.c., p. 64.

[2] Consult the chloroplasts of *Cosmarium Debaryi*, as figured by Lütkemüller in Oesterr. botan. Zeitschrift, 1893, t.3, f.25.

III.—PERIDINIUM ACICULIFERUM, Lemm.

This interesting species was first described by Lemmermann[1] as occurring near Berlin. In a later paper on the phytoplankton of the "Muggelsee"[2] he records it as occurring from February to April, with water-temperatures varying from 2·9°C to 12·1°C. Ostenfeld has also found the species in the plankton of Thingvallavatn in Iceland.[3] It appears in that lake in January and June, having its maximum from February to March with a water-temperature of 1°C.

In the plankton of Bracebridge Pool, *P. aciculiferum* occurred from February to March in 1907, and also from February to March in 1908. In each year it attained its maximum in March (with water-temperatures of 5·0°C and 5·1°C) and completely disappeared before the end of the month. It has thus but a fleeting existence in the plankton, although in March it is one of the dominating constituents.

The occurrence of this species in great abundance in the early spring plankton of a Midland pool is of great interest, as it is essentially a cold-water species, and possibly a northern type. Curiously enough, I have not yet found any trace of it in the spring plankton of the English Lake District, nor in any Welsh or Scottish lake.

P. aciculiferum appears to be well-marked by its three posterior flattened spines. In the general disposition of its plates it agrees closely with *P. umbonatum* Stein, and this fact has recently induced Lemmermann to place it as var. *aciculiferum* of that species[1]. In the Midland specimens the plates were very indistinct. They could always be discerned in the empty cell, but were generally too faint for their exact disposition to be ascertained. The cells are somewhat more compressed than in the majority of the species of this genus, and I find considerable variability in the general proportions of the cell during the great maximum in March. Length of cell 38—48μ; breadth of cell 29—33μ; maximum thickness 22—25μ.

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[1] Lemmermann in Ber. Deutsch. Bot. Ges., 1900, XVIII., p. 28.

[2] Lemmermann. "Brandenburgische Algen., II.," Zeitschrift für Fischerei, XI., 1903, pp. 86—90, 1909.

[3] cf. Ostenfeld & Wesenburg-Lund in Proc. Roy. Soc., Edin., Vol. XXV., Part XII., 1906, pp. 1126—1128. t. 1, f. 11-20.

Towards the end of March thick-walled cysts are formed (Fig. 22 C), which undoubtedly sink to the mud at the bottom of the pool, and there rest until the following January or February. These resting-cysts are ellipsoid with somewhat conical poles, and are evidently of the same nature as the thick-walled cysts described by Ostenfeld[2], although not quite of the same form. The extraordinarily rapid disappearance of *P. aciculiferum* about the end of March must be attributed to the simultaneous formation of large numbers of these thick-walled resting-cysts.

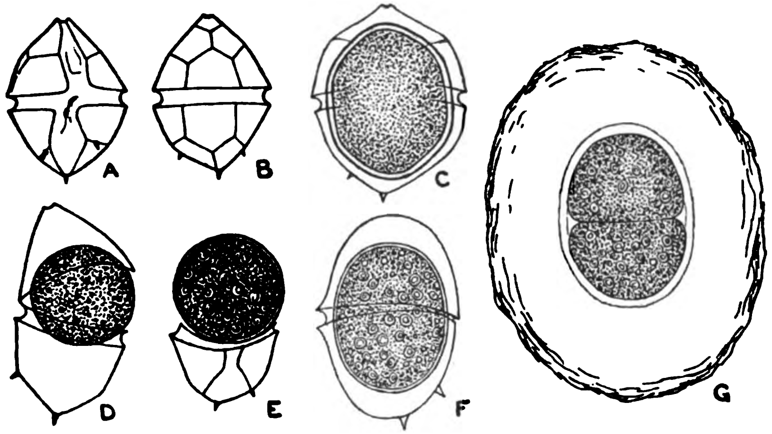

Fig. 22. *Peridinium aciculiferum*, Lemm. A, ventral view; B, dorsal view; C, thick-walled resting-cyst; D—F, thin-walled cysts; G, division of thin walled cyst. All × 500.

During the time of rapid increase of this organism in January or the early part of February, another type of cyst is formed (Fig. 22 D—F). This is not a resting-cyst, but one which almost immediately escapes from the old cell-wall. It becomes invested by a large gelatinous coat and quickly undergoes division (Fig. 22 G). The two new cells rapidly lose the mucous investment and become typical *Peridinia* with a wall composed of plates.

IV.—PERIDINIUM ANGLICUM, SP. N.

In the plankton of Bracebridge Pool this species attained an enormous maximum in the April of both 1907 and 1908. It made its appearance some two or three months before *P. aciculiferum*,

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[1] Lemmermann in Archiv. für Hydrobiol. u. Planktonkunde, IV., 1908, p. 181.

[2] Ostenfeld and Wesenberg-Lund, l.c., p. 1128, t. 1, f. 20.

but although continually on the increase, it did not reach its maximum until a full month after the latter species.

I was quite unable to make the disposition of the plates fit in with any described species of the genus, in consequence of which I sent drawings of it to Mr. Lemmermann of Bremen. He informed me that it appeared to be a new species approaching his *P. Marssonii*[1], and I have given it the name of *P. anglicum*.

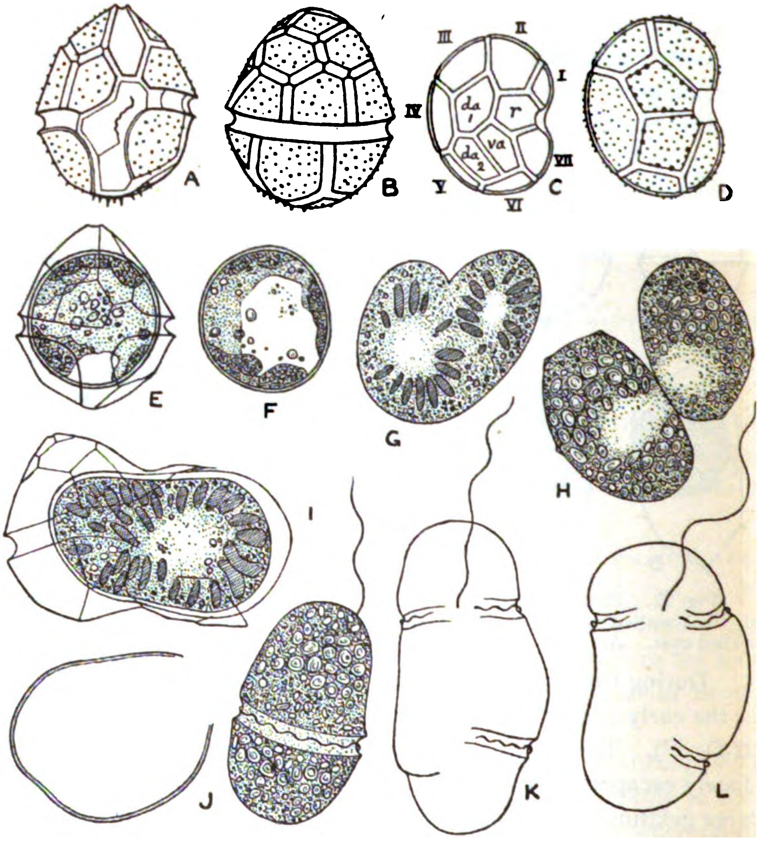

Fig. 23. *Peridinium anglicum*. A, ventral view; B, dorsal view; C, epivalve (anterior half); D, hypovalve (posterior half); E, cyst within old wall; F, escaped cyst; G and H, division of cyst; I, escape of an elongated cyst from old wall; J, escape of motile individual from cyst; K and L, divisions of thin-walled motile state. All × 500.

In Fig. 23 C, I—VII. are the equatorial plates; *r*, the rhomboidal plate; *va*, the ventral anterior (or ventral apical) plate; da_1 and da_2, the dorsal anterior (or dorsal apical) plates.

About the time of its maximum abundance, *P. anglicum* multiplies very rapidly by the production of thin-walled cysts.

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[1] Lemmermann in Ber. Deutsch. Botan. Ges. XVIII., 1900, p. 28.

These are globular and formed singly within the adult cell, from which they soon escape by the rupture of the wall in the vicinity of the equatorial groove. Each cyst possesses a large parietal chromatophore with many lobes (Fig. 23 E and F), or two or three such chromatophores. From this stage the multiplication occurs in two ways.

In the majority of observed instances the non-motile cyst divides, each individual then becoming an adult Peridinium and developing a wall of plates (Fig. 23 G and H). This new wall of plates is often evident before the two individuals have completely separated. Sometimes each of the new cells divides again before the formation of the tabulated wall, so that four individuals are produced from the original cyst.

In other instances the cyst gives rise to a motile *Peridinium*-stage with a very thin wall. This at once escapes from the wall of the cyst (Fig. 23 J) and begins to divide while slowly swimming about (Fig. 23 K and L). Several divisions may occur during this motile stage, the resultant individuals each developing a strong wall of plates and becoming a typical adult *P. anglicum.* The flagella are more obvious during this division than at any period in the life-history of the organism, largely owing to the slowness of their movements. All the divisions which take place in the motile stage are in a transverse plane, so that many curious states can be seen in which the body is much elongated and furnished with two transverse grooves (Fig. 23 K and L). The only figures I can find of division of this nature are those given by Penard[1] of what he doubtfully considered as transverse fission in *Gymnodinium viride.*

So far as I can ascertain, this formation of thin-walled non-resting cysts with the resulting rapid multiplication, both in the non-motile and motile states, is a new observation in the life-history of a thick-walled *Peridinium.* It is certainly the reason for the occurrence of prodigious numbers of active individuals of this species in the April plankton of Bracebridge Pool.

The formation of thick-walled cysts was not observed either at the end of April or in May, when this species is rapidly disappearing. Thin-walled cysts continue to be formed up to the time of this rapid disappearance, and it would seem that the last generation of thin-walled cysts persists through the summer and the early autumn as the resting cysts.

The marginal spines bordering the two antapical (or posterior) plates of the hypovalve (consult Fig. 23 A and D) constitute one of the characteristic features of *P. anglicum*. All the plates are irregularly dotted with very minute spine-like projections.

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[1] Penard in Bull. Soc. Botan. Genève, 1891, t. IV., f. 21; t. 5, f. 8.

Diagnosis:—*Peridinium anglicum*, sp. n. P. circiter 1¼-plo longius quam latum; corpore in partibus subæqualibus duabus a fossa transversa diviso, parte apicali (vel anteriori) rotundo-conica, parte inferiori (vel posteriori) depresso-rotunda; fossa transversa subspiraliter disposita; fossa longitudinali a parte apicali pæne exclusa. *Epivalva* e tabulis 11 composita, tabula rhomboidea juxta apicem extensa; tabulis apicalibus dorsalibus rhomboideo-rectangularibus 2, tabula apicali ventrali rectangulari singula; tabulis æquatoriis 7. *Hypovalva* e tabulis 7 composita; tabulis antapicalibus (posterioribus) æqualibus 2, marginibus spinis conspicuis paucis ornatis; tabulis æquatoriis 5. Tabulæ totæ spinulis minutissimis irregulariter ordinatis et subsparsis ornatæ. Cystæ globosæ vel subglobosæ, membrana glabra. Long. 50-58μ; lat. 42-48μ; crass. max. 33μ; diam. cyst. 35-41μ.

V.—PERIDINIUM CINCTUM Ehrenb. var. LEMMERMANNI.

This is the largest of the *Peridinia* found in Bracebridge Pool, and is easily recognized by its outward form and the disposition and areolation of the plates composing the cell-wall. It is a decided summer or warm-water species, making its first appearance in the plankton in April or May, and attaining its maximum in August or September, with a water-temperature of 17—19°C. From this time there is a rapid decline in numbers, until by the end of October or November the organism has completely vanished.

The formation of thick-walled resting-cysts was observed in October (Fig. 20 J). These were very large, and by the time they were fully formed the old wall of the mother-cell was generally dislocated and partially thrown off.

The specimens agree in the general disposition of the plates with the descriptions and figures of *P. cinctum* Ehrenb., but the six apical plates of the epivalve (va_1, va_2, da_1, da_2, da_3 and da_4) are considerably larger and in consequence occupy a much greater superficial area. The most dorsal of the equatorial plates of the epivalve (No. IV. in Fig. 24 E) is also much larger than in typical *P. cinctum*.

There are altogether fourteen plates composing the epivalve or anterior half of the cell-wall. These cannot all be seen at the same time in a truly anterior view (Fig. 24 D), but in a slightly oblique view they are all visible (Fig. 24 E).

P. cinctum var. *Lemmermanni* attains an enormous maximum in August or September, and as no thin-walled cysts are formed comparable to those observed in *P. anglicum*, this great numerical increase must be due to some other cause. Two possible explanations suggest themselves. The great maximum could be produced by rapid division while in the motile *Peridinium*-stage, but this seems scarcely probable in view of the fact that in this species I have never at any time observed a case of division of the adult motile cell. The most likely explanation is that of a gradually increasing rate of development from the resting-cysts in the period from May to August, culminating in a maximum rate of development in the latter month, accompanied by cell-division in the *Gymnodinium*-stage through which all developing *Peridinia* have to pass.

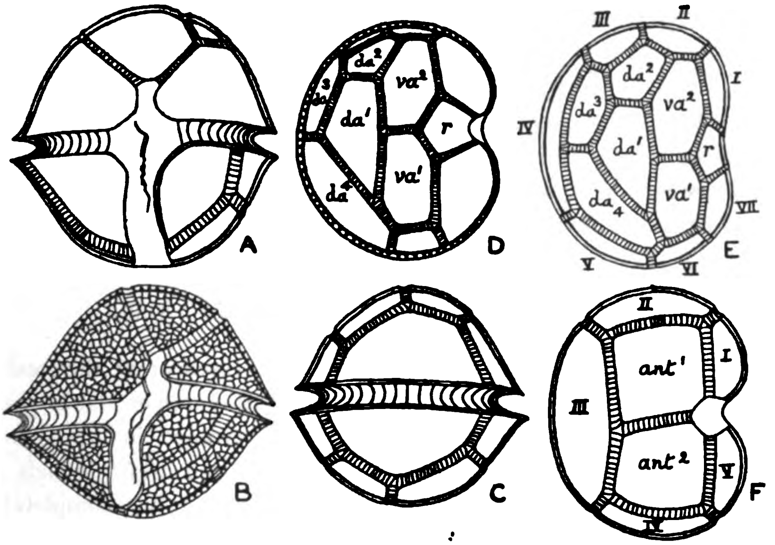

Fig. 24. *Peridinium cinctum* Ehrenb. var. *Lemmermanni* var. n. A and B, ventral views; C, dorsal view; D, epivalve; E, epivalve seen somewhat obliquely; F, hypovalve. The numerals I.—VII. and I.—V. refer to the equatorial plates of the epivalve and hypovalve respectively; *r*, rhomboidal plate; va_1 and va_2, ventral apical plates; da_1—da_4, dorsal apical plates; ant_1 and ant_2, antapical plates. All × 500.

It seems highly probable that many of the records of *P. tabulatum* really refer to *P. cinctum*, as Bergh,[1] Klebs[2], and Penard[3] have all made this error. As the Midland form differs considerably from typical *P. cinctum* in the size and shape of its apical plates, and has retained its features quite constantly for two years, I have named it as a variety.

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[1] Bergh in Morpholog. Jahrbüch, 1881.

[2] Klebs in Arb. botan. Instit. Tübingen, 1883, t. 2, f. 22—24, 28.

[3] Penard in Bull. Soc. Botan. Genève, 1891, t. 2, f. 8—16; t. 3, f. 1—2.

Diagnosis:—*P. cinctum* var. *Lemmermanni.* Cell. differt a forma typica in tabulis apicalibus epivalvæ multe majoribus et in forma iis typicis non plane congruentibus; etiam tabula equatoria dorsali multe majori. Long. 56—70μ; lat. 62—70μ; crass. max. 52—53μ; diam. 58—68μ.

VI.—PERIDINIUM MINIMUM. Schilling.

This minute species occurred only very sparingly in the August and September plankton of Bracebridge Pool in 1908, and most of the specimens seen were dead, empty cells. It has not previously een recorded for the British Islands.

VII.—CERATIUM HIRUNDINELLA. O. F. Müll.

This species, the most ubiquitous and variable of all the freshwater Peridinieæ, is a regular constituent of the summer plankton of Bracebridge Pool. It makes its first appearance in April and gradually increases to a maximum in July or August, after which it rapidly decreases, until by the end of September it has completely vanished. In this pool the maximum is not a large one and the numbers obtained in the tow-nets bear no comparison with the enormous multitudes of *Peridinium anglicum* or *P. cinctum.* It is the first time that this organism has been observed in a British pool of such small dimensions, but its existence as a decided summer form is strictly comparable with its general occurrence throughout Western Europe.

Two distinct forms occur simultaneously, a three-horned and a four-horned form. The latter (Fig. 25 C and D) is a common form in the British lake-plankton[1], and also in the plankton of the lakes of Central Europe,[2] but the former differs in general shape and proportions from any three-horned forms so far recorded from the British Islands. The only published form I have been able to find which approaches this three-horned form from Bracebridge Pool, is the one figured by Lemmermann from certain of the lakes of Sweden.[1]

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[1] W. & G. S. West in Trans. Roy. Soc. Edin. XLI., Part III., 1905, p. 494, c. Fig. 1 C and D; in Trans. Roy. Irish Akad. XXXIII., Sect. B, Part II., 1906, p. 94, c. Fig. 6.

[2] Consult various papers by Lemmermann, Bachmann, Forti, v. Keissler, Wesenberg-Lund, Brunnthaler, etc., etc.

In both 1907 and 1908 *Ceratium hirundinella* formed its characteristic horned resting cysts in September. The increasing size of these cysts during their development causes a dislocation of the cell-wall at the equatorial groove. They apparently rest in the mud at the bottom of the pool from the end of September to the beginning of April.

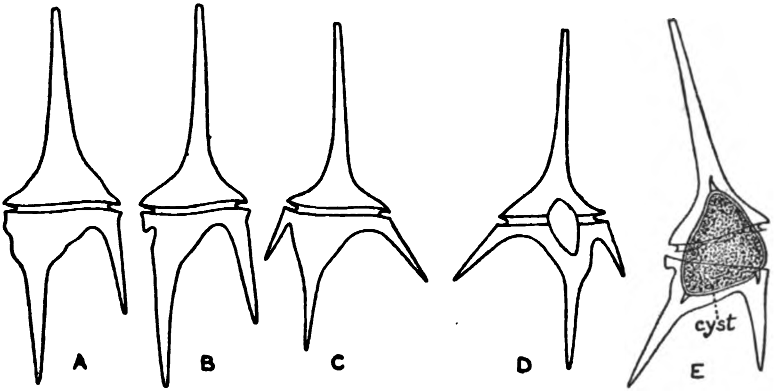

Fig. 25. *Ceratium hirundinella*, O. F. Müll. A and B three-horned form; C and D, four-horned form; E, three-horned form with resting cyst. D is a ventral view; all the other figures are dorsal views. All x 200.

The Periodicity of the Peridinieæ in Bracebridge Pool.

Altogether six species of Peridinieæ were observed in the plankton of this pool, but two of them—*Glenodinium pulvisculus* and *Peridinium minimum*—occurred only in very small numbers in August and September, 1908.

The other four were conspicuous, and three of them dominant constituents of the phytoplankton. The relative frequency of these four species has been plotted out on the accompanying chart (Fig. 26), and it will be noticed that for the years 1907 and 1908 there is a very striking correspondence in the curves. There are two cold-water species and two warm-water species, attaining their maxima in definite sequence each year.

The first one to show activity is *Peridinium anglicum*, which begins in the late autumn, and by January is both numerous and active. Its numbers increase gradually until its great maximum in April. In the meantime, *P. aciculiferum* has appeared, attained a

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[1] Lemmermann in Archiv. för Botanik utgifv. af K. Sv. Vet.-Akad. Bd. II., No. 2, 1904, t. 2, f. 48.

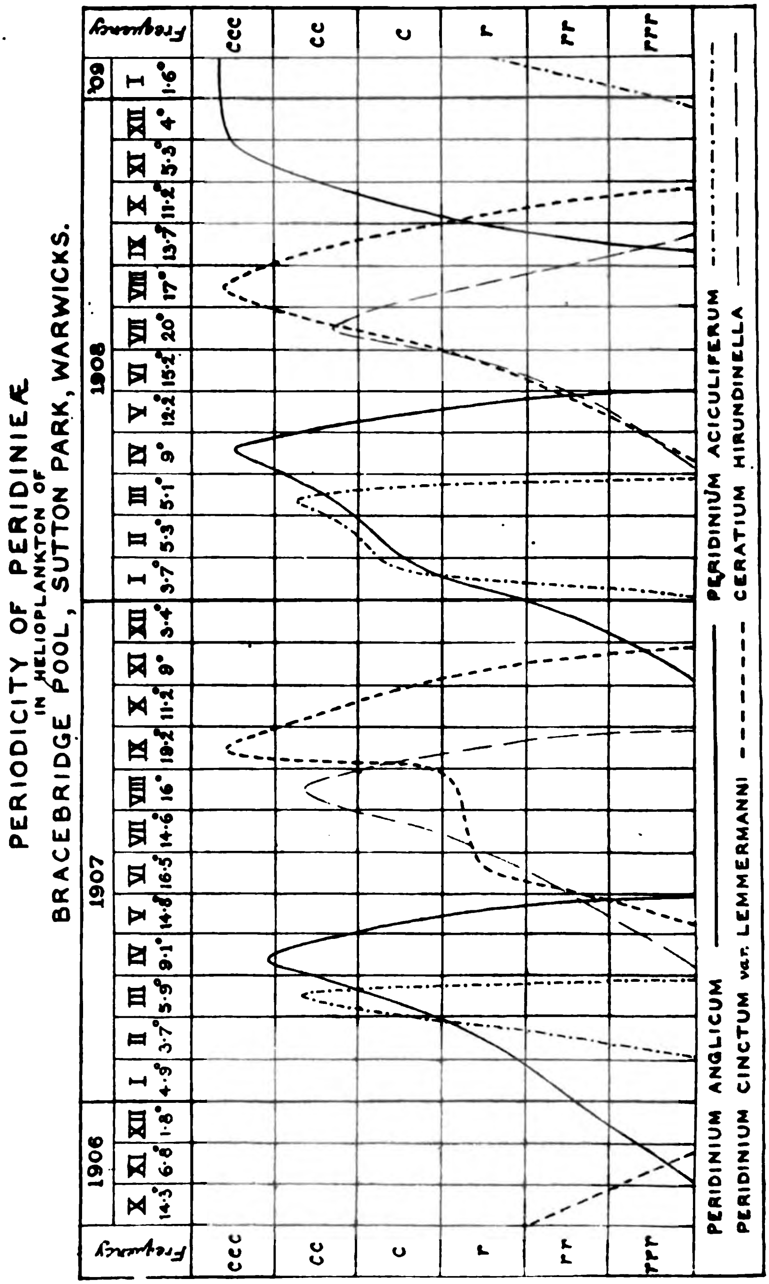

Fig. 26. Chart to show the periodicity of four species of the Peridinieæ, over a period of two years and four months. The temperatures are in degrees Centigrade, and taken six inches below the surface of the water.

great maximum, and disappeared again, all within the short time of two or three months. In 1907 this northern species appeared in February, reached its maximum abundance about the middle of March (temp. 5·9°C), and had completely disappeared before the end of that month. In 1908 it had a similar but slightly longer activity, appearing in January and again attaining its maximum in March (temp. 5·1°C).

P. anglicum very rapidly dimishes after its great maximum in April (temp. about 9°C), and completely disappears by the end of May.

Of the warm-water species, *Ceratium hirundinella* appears first in April, gradually rising to a maximum in July or August (temp. 16—20°C), and quickly disappearing by the end of September.

Peridinium cinctum var. *Lemmermanni* begins its activity in April or May, attains its great maximum in August or September (temp. 17—19°C), and then rapidly and completely disappears by the end of October or November.

It will be noticed from the chart that all four species disappear very rapidly, the curves all having very steep downward slopes. This is to be attributed in every instance to the rapid formation of resting-cysts at the close of the active period. In two species the encysted stage is induced by the vernal rise of temperature, and in the other two species by the autumnal fall of temperature.

Horned cysts were only observed in *Ceratium hirundinella*, and the formation of lunate cysts, with produced and spinate extremities such as those described and figured by Stein[1] in *Peridinium tabulatum* and by Schilling[2] in *Glenodinium cinctum*, was not seen in any species of *Peridinium* in the two years these organisms were under observation.

A curious irregularity is noticeable towards the end of 1908. In this year *Peridinium anglicum* appears to have had a resting period of only a little over three months. It recommenced its activity in September and very rapidly attained a great maximum in November, which it maintained throughout December, 1908, and January and February, 1909. This deviation from the general seasonal periodicity of the organism (as shown during the two previous years) is partly due to the early cold of the autumn of 1908, which was continued right through the winter. At the same time, this does not explain the maintenance of an enormous maximum through the cold period (4°—1°C) when in both the preceding years the greatest maximum was attained at a temperature of approximately 9°C.

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[1] Stein, Der Organismus der Infusionsthiere, Abth. III., Hälfte II., 1883, t. 12, f. 20—28; t. 13, f. 1—5.

[2] Schilling, l.c. t. 2, f. 28—30; t. 3, f. 3—4b.

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1909a

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The British Freshwater Phytoplankton, with Special Reference to the Desmid-plankton and the Distribution of British Desmids.

BY W. WEST, F.L.S., AND G. S. WEST, M.A., D.Sc., F.L.S.

p165

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By W. West, F.L.S., and G. S. West, M.A., D.Sc., F.L.S.

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I. Introduction.

Not until much work had been done at the phytoplankton of the freshwaters of Western Europe were investigations of a similar nature begun in the British lakes and rivers, and it is during the last ten years that almost all our knowledge of this branch of freshwater biology has been acquired.

We have ourselves conducted nearly all the British investigations, and we now think the work has progressed sufficiently to enable us to summarise the results, and to institute comparisons between the British phytoplankton and that of continental Europe and other regions.

Since 1900 we have collected plankton from a large number of lakes in the west of Scotland, from some of the lowland Scottish lochs, from practically all the lakes of the English Lake District and most of those in North Wales, from nearly all the lakes of the west and south-west of Ireland, from Lough Neagh and Lough Beg, from Malham Tarn in West Yorkshire, and from the Rivers Ouse, Lochay, and Bann. In the collection of material for these investigations we have been greatly assisted by four grants from the Government Grant Committee of the Royal Society and two from the Fauna and Flora Committee of the Royal Irish Academy.

From a biological standpoint the British lakes are of great interest, and since the publication of the first reports on their plankton, the diversity of the Algal constituents has been a revelation to the freshwater biologist. In the number and diversity of the species constituting this phytoplankton the lakes of the western British areas stand ahead of any other lakes which have so far been investigated.

The numerous Scottish lakes are almost all of a montane character. They are situated in the vicinity of high mountains and in a northern latitude, and many of the higher plants occurring in these localities in abundance, at almost sea-level, are typical montane species.*

The lakes of the four principal areas examined, the North-west Scottish, the West and South-west Irish, the Welsh, and the English lakes, are situated in the most mountainous parts of the British Islands. As these areas contain the great majority of the British lakes, and are all geographically in the west or north-west, they can be spoken of as the *western and north-western lake-areas.* The mountains amongst which they are situated are composed almost entirely of old formations, and the lake-basins are for the most part drainage areas on outcrops of Older Palæozoic or of Precambrian rocks, often with associated intrusive Igneous masses.

Malham Tarn, West Yorkshire, and Lough Neagh are somewhat isolated lakes, and their phytoplankton is considered separately.

Wherever possible, boats were used for the collection of the plankton, and for one part of the investigation of Lough Neagh, the Lough Foyle and River Bann Fisheries Company kindly lent a steam launch. The smallest tow-net had a mouth-diameter of 6 inches and a length of 15 inches, the largest was 12 inches diameter and about 36 inches in length. The nets were usually towed after the boat at a speed of about 1½ to 2 miles per hour, but on Lough Neagh the large nets were used up to a speed of 4 miles per hour. They were generally kept in the water from 20 to 30 minutes.

We have come to the conclusion that *the best fixing agent is 2 or 3 per cent. formalin, but it should always be replaced before the material is examined.*

Neither picric acid nor chromic acid should be used in plankton-work, as it is almost impossible to wash the material free from these reagents by ordinary methods, and *all the gelatinous colonies are broken up.* Alcohol is also to be avoided, as it causes too great a shrinkage and distortion of the more delicate plankton species.

During the past 18 years we have been acquiring a very extensive knowledge of the distribution of British freshwater Algæ, having made many thousands of collections in all parts of the British Islands. As the lake-areas are the richest parts of the country for freshwater Algæ, these districts have been worked very extensively, and as we did not begin plankton investigations until 1900, we have a much more complete knowledge of the general Algæ-flora of these areas—such as is found in the bogs, lake-margins, streams, on the wet rocks of the glens, etc.—than of the phytoplankton. In consequence of this previous detailed acquaintance with the Algæ of the lake-areas, we are enabled with a considerable degree of accuracy to state which species should be considered as *true constituents of the plankton* and which should not. The other constituents are *casual or adventitious*, and their sojourn in the plankton is both temporary and accidental.

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* Occurring in abundance around these lakes are:—*Festuca ovina*, var. *vivipara*, *Andreæa Rothii*, *A. petrophila*, *Bryum alpinum*, various species of *Rhacomitrium*, *Anthelia julacea*, *Platysma triste*, *Cladonia cervicornis*, *Stereocaulon coralloides*, *Sphærophoron coralloides*, *Lecidea geographica*, etc. The whole district is almost treeless.

The work has been entirely of a qualitative character. We have had neither the time nor the necessary funds to conduct quantitative investigations such as those carried out by Apstein,[*] Zacharias,[†] Lemmermann,[‡] Volk,[§] etc., in Germany, by Wesenberg-Lund[||] in Denmark, by Huitfeldt-Kaas[¶] in Norway, and by others in Switzerland and the United States.[**]

We have also met with many difficulties in attempting to acquire a knowledge of the periodicity of the plankton of the British lake-areas. Neither academic duties nor funds have permitted the necessary number of visits to these areas which would be required in the course of a year in order to obtain an adequate idea of the periodicity of the plankton. At the very least, monthly visits would be imperative for reliable results to be obtained; and to collect material from a number of lakes, even in one district, would require several days, not to mention the difficulty, and in some cases the impossibility, of obtaining boats in the winter months. It is likewise no easy matter to find suitable men on the spot of sufficient intelligence to carry out detailed instructions at regular monthly intervals throughout the year.[††]

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[*] Apstein, 'Das Süsswasserplankton, Methode und Resultate der quantitativ. Untersuchung.,' Kiel und Leipzig, 1896.

[†] Zacharias in 'Forschungsber. Biol. Stat. Plön,' vol. 3, 1895, etc.

[‡] Lemmermann, "Das Plankton der Weser bei Bremen," 'Archiv für Hydrobiologie und Planktonkunde,' Bd. 2, 1907.

[§] Volk, "Hamburgische Elbe-Untersuchung., I u. VIII," 'Mitteilungen aus dem Naturhist. Mus. Hamburg,' Bd. 19, 1903; Bd. 23, 1906.

[||] Wesenberg-Lund, 'Studier over de Danske Söers Plankton, Kjöbenhavn,' 1904.

[¶] Huitfeldt-Kaas, 'Planktonundersögelser i Norske Vande,' Christiania, 1906.

[**] C. Dwight Marsh, in 'Wisconsin Geol. and Nat. Hist. Survey Bull.,' No. XII, 1903; Kofoid, in 'Bull. Illinois State Laboratory of Nat. Hist.,' vol. 8, 1908.

[††] We are at present receiving regular periodic collections, with some necessary data, from several of the Scottish lochs and from some of the lakes of the English Lake District. We have been able to arrange for these collections by means of a further grant from the Royal Society. Periodic collections have also been made for a period of two years from one of the large pools of the Midlands. The details of all these collections will be published shortly.

II. SCOTTISH LAKES.

Extensive collections of phytoplankton were made in various parts of Scotland, but especially in the west and north-west, in August, 1901, May and August, 1902, April, July, August, and September, 1903, and August, 1907. The areas comprised Perth, Inverness, Ross, Sutherland, and the Outer Hebrides. We have also examined a number of collections made by Mr. James Murray of the Scottish Lake Survey (Pullar Trust). In all, we have examined phytoplankton from 38 of the most important of the Scottish lochs. The results of these investigations have already been published,* the previous work being represented by a short report by Borge on some phytoplankton from the Island of Mull.† Mr. James Murray has also examined the plankton of a very large number of the Scottish lochs, and has at different times commented upon the occurrence and distribution of the phytoplankton.‡ Further remarks upon the Scottish phytoplankton have been made by Wesenberg-Lund in comparing it with the plankton of the Danish lakes,§ and still more recently a paper has appeared by Bachmann‖ comparing the results of Scottish material with plankton from the Swiss lakes.

The Scottish phytoplankton is largely Chlorophyceous, and is conspicuous for the large number and great variety of its Desmids, among which the following are perhaps the most noteworthy: *Xanthidium subhastiferum*, *Staurastrum anatinum*, *St. Ophiura*, and *St. jaculiferum*. In some of the lochs, *Mesotænium macrococcum* occurred as a normal constituent of the plankton. This is a most interesting adaptation of a colonial wet-rock species to a limnetic life, with an accompanying reduction in size of the colonies and their assumption of a spherical form. A similar adaptation of the mucous colonies of *Cosmocladium saxonicum* to a limnetic existence is also found in both the Scottish and the Irish lakes, but much less frequently.

In the smaller and more elevated lochs, *Microspora amœna* is a characteristic constituent of the plankton, and sterile filaments of slender species of *Spirogyra*, *Zygnema*, and *Mougeotia* occur in abundance. The more slender species of *Mougeotia* are generally the most abundant of these filamentous Algæ, and in some instances they exhibit a coiling of the filaments such as is known to occur in certain of the plankton-forms of *Melosira*. (Consult fig. 1.)

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* W. and G. S. West, in 'Linn. Soc. Journ. Bot.,' vol. 35, Nov., 1903; in 'Roy. Soc. Edin. Trans.,' vol. 41, part 3, 1905.

† Borge, 'Algol. Notis. 4, Süssw.-Plankton aus Insel Mull,' Botaniska Notiser, 1897.

‡ *Vide* James Murray, in 'Roy. Physical Soc. Edin. Proc.,' vol. 16, June, 1905; and in various reports, under the direction of Sir John Murray, on the Bathymetrical Survey of the Freshwater Lochs of Scotland in the 'Geograph. Journ.,' 1900—1908.

§ Wesenberg-Lund, in 'Roy. Soc. Edin. Proc.,' vol. 25, part 6, 1905; also in appendix to a subsequent paper, *ibid.*, part 12, 1906.

‖ Bachmann, in 'Archiv für Hydrobiol. u. Planktonkunde,' vol. 3, 1907. It should be mentioned, however, that some of Bachmann's records are open to serious doubt. His identifications do not appear to be strictly accurate. We might ask, among many other questions, "What is *Cosmarium lunaria*?" He also copies Tanner-Fulleman's records, some of which appear to be equally doubtful.

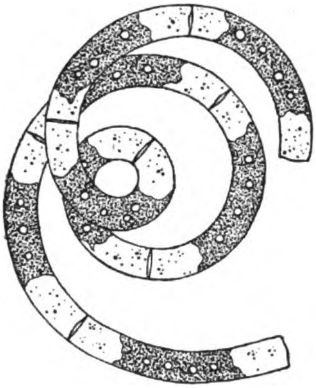

Fig. 1.—A Coiled Filament of one of the Sterile Species of *Mougeotia* from the Scottish Plankton. × 300.

The Protococcoideæ are not very abundant in the deeper Scottish lochs most of them having a decided preference for shallower and warmer water. The most frequent are *Botryococcus Braunii*, *Sphærocystis Schroeteri*, *Glœocystis gigas*, and *Ankistrodesmus falcatus*.

Diatoms are conspicuous, largely due to the occurrence in quantity of a few species. They occur throughout the spring and summer in large numbers in the deeper lochs, as the temperature of the water never becomes very high. Many of them are adventitious constituents washed into the plankton from the bogs and shores, but some have become established as true plankton-species. There are about 18 well-established species in the plankton, but only the three species of *Rhizosolenia* are of exclusive limnetic habit, all the remainder occurring in other situations.

The Myxophyceæ (Blue-green Algæ) are very poorly represented in the deeper lochs, and are by no means abundant in the smaller, shallower lakes. The phenomenon of "water-bloom" is very rarely met with, and discoloration of the water, even of the smaller lakes, does not occur either very often or with any great regularity as the result of the accumulation of large quantities of Blue-green Algæ.

The only periodic collections which have so far been reported upon were those made in Loch Ness and examined by Bachmann,* and our own observations relative to the periodicity of the Scottish phytoplankton are amply confirmed by Bachmann's brief report.

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* Bachmann, *loc. cit.*, 1907, pp. 85—88.

Desmids are the dominating constituents in the late summer and early autumn, and there is a preponderance of Diatoms in the colder months, but compared with the seasonal variations of the phytoplankton in some lakes, these differences are not very conspicuous.

Specimens of *Dinobryon* occur in quantity in the spring and summer, and the Peridinieæ are represented by 11 species, although in the larger lakes they are by no means numerous.

Of a total number of 354 species observed in the phytoplankton, 49·4 per cent. are Desmidiaceæ, 17·7 per cent. are Bacillarieæ, and 8·7 per cent. are Myxophyceæ.

III. Lakes of the Orkneys and Shetlands.

We have examined material from one freshwater loch in the Orkneys and from six in the Shetlands. The collections were made in August, 1903, and the results published in 1905.[*] Mr. James Murray has collected material from 34 lochs of the Orkneys and Shetlands, and has briefly noted a few species of the phytoplankton.[†]

Although containing a considerable number of species, the phytoplankton was not very rich. Most of the lochs were shallow, and contained quantities of *Asterionella formosa*. *Pediastrum Boryanum* and *Scenedesmus quadricauda* were both fairly common. Colonies of a *Crucigenia*, described by Wille from the Norwegian plankton as *C. irregularis*,[‡] but most probably only irregularly developed forms of *C. rectangularis*, occurred in several lochs of the Shetlands.

Desmids were frequent, and in some cases numerous, but the species were mostly those of shallow lowland lakes. The characteristic western British types were absent, although further investigations in the Shetlands would no doubt bring some of them to light.

Peridinieæ were abundant, as is so frequently the case in shallow lakes, and the ubiquitous *Ceratium hirundinella* was much more generally abundant than in the larger Scottish lakes.

Out of 52 species of Algæ described by Börgesen and Ostenfeld[§] as occurring in the plankton of the Faeroese lakes, 28 were observed in the plankton of the Orkneys and Shetlands.

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[*] W. and G. S. West, in 'Bot. Soc. Edin. Trans.,' Nov., 1904 [1905], pp. 5—10.

[†] James Murray, in 'Roy. Soc. Edin. Proc.,' June, 1905, pp. 55, 56.

[‡] Wille, in 'Nyt Magazin for Naturvidenskb.,' Bd. 38, Heft 1, 1900, p. 10, t. 1, f. 15. Consult also the remarks of G. S. West, 'Treatise Brit. Freshw. Alg.,' 1904, p. 217; and Ostenfeld in 'Hedwigia,' vol. 46, 1907, p. 383.

[§] F. Börgesen and C. H. Ostenfeld, "Phytoplankton of Lakes in the Faeroes," 'Botany of the Faeroes,' Copenhagen, 1902.

Of a total of 178 species observed in the phytoplankton, 47·4 per cent. were Desmidiaceæ, 20·9 per cent. were Bacillarieæ, and 9·6 per cent. were Myxophyceæ.

IV. The Irish Lakes (West and South-west).

In 1906 we published an account of the plankton of some of the more important lakes of the West and South-west of Ireland,* from collections which we made in May, August, and September, 1904.

In the summer the phytoplankton is greatly in excess of the zooplankton, and the Entomostraca are only dominant in the early spring months. As in the Scottish lakes, the phytoplankton of the lakes of the west and south-west of Ireland is to a large extent Chlorophyceous, but the Bacillarieæ, the Peridinieæ and to some extent the Myxophyceæ, are also conspicuous. The latter are much more noticeable than in the Scottish plankton, especially species of *Anabæna, Oscillatoria, Gomphosphæria, Cœlosphærium,* and *Chroococcus.*

The Desmids are numerous, and include many of the characteristic western types. There is a great abundance of *Spondylosium pulchrum,* var. *planum, Staurastrum anatinum, St. jaculiferum, St. Arctiscon, St. pseudopelagicum,* and *St. paradoxum,* var. *longipes,* but a curious absence of *St. Ophiura.* The latter is a feature of a large proportion of the Scottish phytoplankton, but we have not yet observed it in the Irish lakes. In the lakes examined, the Desmid-flora of the plankton was not quite so rich as that of some of the Scottish lakes, but we think that an investigation of many of the smaller lakes of Galway and Mayo would bring to light a phytoplankton not at all inferior to that of the western Scottish lochs.

Diatoms are very abundant, and form a relatively large part of the Irish phytoplankton. Centric Diatoms are more numerous than in the Scottish plankton, and are represented chiefly by species of *Melosira* and *Cyclotella. Tabellaria, Asterionella,* and the narrow forms of *Synedra* are very conspicuous in the Irish lakes.

The Peridinieæ are generally abundant, and are represented by 10 species. Much the most interesting of these is *Peridinium limbatum* (fig. 2), a characteristic horned species which occurred in some of the small lakes of Galway. It has only been found elsewhere in the United States.

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* W. and G. S. West, "A Comparative Study of the Plankton of some Irish Lakes,' 'Roy. Irish Acad. Trans.,' vol. 33, sect. B, part 2, 1906.

Of a total of 246 species observed in the phytoplankton, 41·7 per cent. were Desmidiaceæ, 19 per cent. Bacillarieæ, and 13·3 per cent. Myxophyceæ.

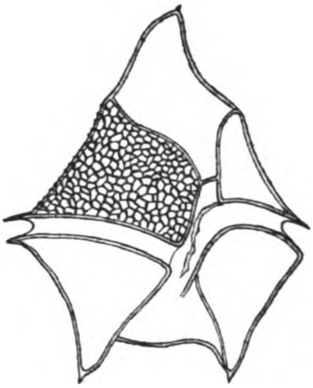

Fig. 2.—*Peridinium limbatum* (Stokes), Lemm., from the Plankton of a small Lake between Clifden and Roundstone, Galway. × 500. The reticulated surface markings of the cell-wall are only indicated on one of the plates.

V. Lough Neagh.

The first contribution to the plankton of the Irish lakes was an account of the plankton-Algæ of Lough Neagh and Lough Beg,* the material having been collected in May, 1900, and July, 1901. This material has since been subjected to a further examination. The lake is so isolated, and, moreover, so differently situated from the other Irish lakes examined, that we have kept the records in a separate column in the tabulated list of British phytoplankton. It is also of interest as being the largest lake in the British Islands; but although covering a large area it is very shallow, its average depth being only 45 feet, and the deepest sounding (made in the north-west corner), is only 96 feet.

The phytoplankton consists largely of Diatoms, Peridinieæ, and Chlorophyceæ. Of the latter, a few of the Desmids characteristic of shallow lakes are abundant, and *Staurastrum paradoxum*, var. *longipes*, occurs in prodigious quantity. *St. pelagicum* was first described from this lake, and has since been found in the lakes of Germany and Iceland. The Protococcoideæ are very well represented, species of *Cœlastrum*, *Pediastrum*, and *Oocystis* being especially noticeable. Of the Diatoms, *Tabellaria fenestrata*, var. *asterionelloides*, is the most conspicuous, but *Coscinodiscus lacustris*, *Cymatopleura elliptica*, and species of *Surirella* are also abundant. The Myxophyceæ are well represented by species of *Anabæna* and *Oscillatoria*, the narrow limnetic species of *Lyngbya*, species of *Cœlosphærium*, *Gomphosphærium*, and *Aphanothece*; and *Chroococcus limneticus* is abundant. Three species of *Dinobryon* are fairly common, but we have no evidence to show whether they ever become dominant or not.

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* W. and G. S. West, "A Contrib. to the Freshw. Alg. of the North of Ireland," 'Roy. Irish Acad. Trans.,' vol. 32, sect. B, part 1, 1902.

On the whole, the phytoplankton is a combination of that which occurs in shallow lakes with that of large pools and ponds. Out of a total of 128 species observed in it, 17·1 per cent. were Desmidiaceæ, 25·7 per cent. other Chlorophyceæ, 32 per cent. Bacillarieæ, and 16·4 per cent. Myxophyceæ.

VI. THE WELSH LAKE-AREA.

Plankton collections were made from 19 of the Welsh lakes, mostly those of Carnarvonshire, during June, 1905, August and September, 1906, and April, 1908.*

The phytoplankton of the spring and summer is essentially Chlorophyceous, and as in the case of the Scottish lakes, is especially noteworthy for the abundance of its Desmids. There is little bulk even in the summer plankton, and in general it has practically no effect on the colour of the water. *The Desmid-flora in certain of these lakes is equal to that found in the richest lakes of the north-west of Scotland, and in one case*—the Capel Curig Lakes—*is superior to that known from any other lake in the world which has been biologically investigated.*

Of a total of 162 species which we have observed in the phytoplankton of the Welsh lakes no fewer than 101 are species of Desmids.

The Protococcoideæ are relatively few, both in number of species and individuals, *Ankistrodesmus falcatus* and *Botryococcus Braunii* being the most frequent.

Diatoms are not conspicuous, and there are fewer species in the Welsh plankton than in either the Scottish or Irish lakes.

Apart from the spasmodic occurrence in fair quantity of one or two species of *Anabæna*, and the moderate abundance of *Oscillatoria Agardhii*, the blue-green element is distinctly scarce in the Welsh plankton.

Species of *Dinobryon* and various Peridinieæ occur abundantly in the Welsh lakes. *Ceratium cornutum* is more abundant than in any other part of the British Islands.

There is no great development of peat in this Welsh lake-area, and the water of the lakes is for the most part clear and limpid. The drainage is mostly down steep mountain sides, with occasional bogs and boggy pools.

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* **The details of these collections are being published separately.**

The Capel Curig lakes merit special mention. The summer plankton is almost a pure Desmid-plankton, and consists largely of those rare and handsome species which are almost exclusively confined to the west-coast districts of the British Islands. The following species occur in great abundance :—*Micrasterias radiata*, *Staurastrum anatinum*, *St. aversum*, *St. Arctiscon*, *St. Cerastes*, *St. longispinum*, and a stout variety of *St. Ophiura*. It is interesting to note that *St. anatinum* is present in prodigious abundance, as it was from the littoral region of this lake, near the outlet, that it was originally described. *Micrasterias radiata* exists in myriads in the plankton of this lake, occurring in a profusion unknown in any other of its British localities.

Mixed with the Desmids are numbers of *Ceratium cornutum*, and a very few individuals of *Tabellaria fenestrata* and *T. flocculosa*.

Of a total of 162 species observed in the Welsh phytoplankton, 62·4 per cent. were Desmidiaceæ, 11·1 per cent. Bacillarieæ, and 7·4 per cent. Myxophyceæ.

VII. The English Lake-area.

Plankton collections were made from 18 of the English lakes in June, 1903, and September, 1906; and since then periodic collections have been commenced in Windermere, Ennerdale Water, and Wastwater.*

As in the Welsh lakes, the phytoplankton of the spring and summer is essentially Chlorophyceous, and contains numerous Desmids, but although most of the typical British plankton-Desmids occur, they are not represented by so many species as in the Scottish or Welsh lakes. The most frequent are the spiny species of *Staurastrum*, *St. lunatum*, var. *planctonicum*, *St. Arctiscon*, *Xanthidium antilopæum*, *Cosmarium subtumidum*, var. *Klebsii*, and *Spondylosium pulchrum*, var. *planum*. The presence of *Staurastrum Ophiura* in the plankton of Easdale Tarn is particularly interesting, as this Desmid is not known to occur in any of the bogs of the English lake-area.

The Protococcoideæ are somewhat scarce, *Glœocystis gigas* and *Sphærocystis Schroeteri* being the only generally distributed species, and these only in small quantity.

The Bacillarieæ and Myxophyceæ are represented by relatively few species, but in some of the lakes Diatoms are dominant constituents of the plankton. Particularly is this the case in Ullswater, in which *Asterionella formosa* was the dominant constituent of both the May and September plankton.

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* As no work has previously been done at the plankton of the English lakes, only the list of species is given for comparison with those of the other British lake-areas. The details of the investigations are reserved for special publication.

Species of *Dinobryon* are common, especially in the early summer plankton. In the May and June plankton of Crummock Water and Derwent Water *Dinobryon cylindricum*, var. *divergens*, completely dominated all other constituents.

Comparison of precisely similar plankton-samples from the various lakes of the English Lake District shows clearly that the proximity of habitations has a distinct effect on the relative bulk of the plankton. *Those lakes which are contaminated by the presence of numerous dwellings and villages along or near the shores possess a relatively greater bulk of plankton than those free from contamination.* The explanation of this fact is most probably the increased amount of nitrates in the water of the contaminated lakes.

Out of 188 species observed in the phytoplankton, 51 per cent. were Desmidiaceæ, 21 per cent. were Bacillarieæ, and 9·5 per cent. Myxophyceæ.

VIII. MALHAM TARN, WEST YORKSHIRE.

This lake is the largest natural sheet of water in Yorkshire and covers an area of 153 acres. It is situated on a limestone plateau at an altitude of 1250 feet, and there is an extensive peat-bog at its northern extremity.

The material was collected by boat on July 23, 1904.

Out of a total of 20 species observed in the phytoplankton nine were Desmids. *Sphærocystis Schroeteri* was very abundant and *Volvox aureus* rather common. Only one Diatom was observed, and four Blue-green Algæ. *Ceratium hirundinella* was very common.

The following is a complete list of the species observed:—*Mougeotia* sp. (sterile), *Gonatozygon monotænium*, *Cosmarium Botrytis* and var. *depressum*, *C. depressum*, *Staurastrum Avicula*, var. *subarcuatum*, *St. brevispinum*, *St. furcigerum*, *St. Manfeldtii*, *St. paradoxum*, *St. teliferum*, *Volvox aureus*, *Pediastrum Boryanum*, *Sphærocystis Schroeteri*, *Surirella biseriata*, *Oscillatoria Agardhii*, *Microcystis æruginosa*, *Merismopedia elegans*, *Chroococcus limneticus*, *Ceratium hirundinella*, and *Peridinium* sp.

IX. THE BRITISH RIVER-PLANKTON.

The first account of British river-plankton (*potamoplankton*) was the comparison of that found in the Upper River Bann with that of Lough Neagh,* and since then Fritsch† has published an account of the phytoplankton of the Rivers Thames, Trent, and Cam. We have also examined the plankton of the Rivers Ouse, Avon, and Cam in England, and the River Lochay in Scotland.

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* W. and G. S. West, in 'Roy. Irish Acad. Trans.,' vol. 32, sect. B, part 1, 1902.

† Fritsch, in 'Ann. Bot.,' vol. 16, Sept., 1902; *ibid.*, vol. 17, Sept., 1903; *ibid.*, vol. 19, Jan., 1905.

It would appear that some phytoplankton occurs all the year round in the British rivers, due mostly to the absence of severe winters, and that in the winter months the living constituents are mostly Diatoms. In fact, *Diatoms dominate throughout the entire year*, the most important genera being *Asterionella, Synedra, Melosira, Surirella*, and *Fragilaria*. Fritsch* summarises the phytoplankton of the Thames in the course of a year as follows:—

Mixed Plankton (with *Asterionella*-phase) → *Melosira* → *Synedra* → Mixed Plankton.

We find *Melosira varians* conspicuous in the spring-plankton of British rivers and persisting in quantity through the summer until the late autumn. *Synedra Acus* is one of the dominant summer species in the British rivers, although it is a spring or an autumn form in the Oder, the Danube, and the Illinois River. *Surirella biseriata* and *S. robusta*, var. *splendida*, are often conspicuous in the summer-plankton, the former being the more abundant, which is never the case in the lake-plankton.

Certain Protococcoideæ occur in the late summer, but never in great quantity. Species of *Pediastrum, Scenedesmus*, and a few other genera are the most frequent, and occasionally odd specimens of a *Cosmarium* or a *Closterium* may occur.

Flagellates and some of the Volvocaceæ occur mostly in the spring months and generally attain their greatest abundance before the maximum summer temperatures. *Eudorina elegans* is most irregular in its occurrence, and is often found in quantity in midsummer or even in early autumn. We have never found the Volvocaceæ so numerous in river-plankton as they often become in the plankton of lakes and pools. *Pandorina morum* is the most frequent both in the rivers and small pools.

The backwaters of the rivers are largely the breeding-places of the plankton-organisms, and as pointed out by Kofoid, their contributory function to the plankton of the river is at its maximum during *the decline of the floods*. It is during such times that vast accumulations of plankton-units are carried into the main stream.

Melosira varians, Fragilaria capucina, and *Cyclotella Kützingiana* are perennial plankton-organisms in the rivers we have examined.

X. GENERAL COMPARISON OF BRITISH LAKE-AREAS.

In summarising our present knowledge of the phytoplankton of the British lakes, it has been one of our first duties to obtain a record of the species which occur in the different areas. As these records have never previously been correlated, we have drawn up the following tabulated list of all the species observed in the phytoplankton of the British Islands.

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* Fritsch, *loc. cit.*, 1903, p. 637.

In this list those Algæ, which, so far as is known, are *exclusively confined to the plankton* are marked "P"; those which are *exclusively plankton-varieties* of species which frequently occur in other situations are marked "Pv"; and those species which are *more abundant in the plankton than elsewhere* are marked "p."

Species.	Scottish lakes.	Orkneys and Shetlands.	W. and S.W. Ireland.	Welsh lakes.	English lakes.	Lough Neagh (and L. Beg).
CHLOROPHYCEÆ.						
Œdogonium spp. (sterile)	×	×	×	×	×	×
,, ***punctato-striatum***, De Bary	×					
Ulothrix zonata (Web. and Mohr), Kütz.	×	—	—	—	×	
,, ***subtilis***, Kütz.	—	—	—	—	—	×
,, ,, var. ***variabilis*** (Kütz.), Kirchn.	×	×	×	×	×	
,, ***moniliformis***, Kütz.	×	×				
Geminella interrupta, Turp.	×	—	×			
Myxonema subsecundum (Kütz.), Hazen.	—	—	×			
,, ***tenue*** (Ag.), Rabenh.	—	—	—	—	—	×
Microspora amœna (Kütz.), Lagerh.	×	—	×	×	×	
,, ,, var. ***irregularis***, W. and G. S. West	—	—	×			
,, ***abbreviata***, Rabenh.	—	—	—	×	×	
Mougeotia spp. (sterile)	×	×	×	×	×	×
,, ***elegantula***, Wittr.	×	—	—	—	×	
Zygnema spp. (sterile)	×	—	×	×	×	
,, ***ericetorum*** (Kütz.), Hansg.	×					
Spirogyra spp. (sterile)	×	—	×	×	×	
Debarya glyptospermu (De Bary), Wittr.	—	×				
Gonatozygon monotænium, De Bary	×	×	×	×	×	
,, ,, var. ***pilosellum***, Nordst.	×	—	×	×	×	
,, ***Brébissonii***, De Bary	—	—	—	×		
,, ***Kinahani*** (Arch.), Rabenh.	×	×	×	×		
,, ***aculeatum***, Hastings	×					
Genicularia elegans, W. and G. S. West (P)	×					
Spirotænia condensata, Bréb.	—	—	—	×		
Mesotænium macrococcum (Kütz.), Roy and Biss.	×	—	×			
Cylindrocystis diplospora, Lund.	×					
,, ,, var. ***major***, West	—	—	—	—	×	
Netrium Digitus (Ehrenb.), Itzigs. and Rothe	×	×	×	×	×	
Penium Libellula (Focke), Nordst.	×	—	×			
,, ,, var. ***interruptum***, W. and G. S. West...	—	—	—	×		
,, ***minutum*** (Ralfs), Cleve.	×	×	×	—	×	
,, ***margaritaceum*** (Ehrenb.), Bréb., var. ***irregularius***, W. and G. S. West	—	×				
,, ***truncatum***, Bréb.	—	—	—	—	×	
Closterium abruptum, West	—	×				
,, ***acutum***, Bréb.	×	—	—	—	×	×
,, ***aciculare***, T. West, var. ***subpronum***, W. and G. S. West (p)	×	—	×	—	—	×
,, ***acerosum*** (Schrank), Ehrenb.	—	×				
,, ,, var. ***minus***, Hantzsch	×	—	×			

Species.	Scottish lakes.	Orkneys and Shetlands.	W. and S.W. Ireland.	Welsh lakes.	English lakes.	Lough Neagh (and L. Beg).
Closterium Ceratium, Perty	—	—	—	—	—	×
,, *Cornu*, Ehrenb.	—	×				
,, *Cynthia*, De Not	—	×				
,, ,, var. *curvatissimum*, W. and G. S. West	×					
,, *decorum*, Bréb.	—	—	×			
,, *Dianæ*, Ehrenb.	×	—	—	—	×	
,, *Ehrenbergii*, Menegh.	×					
,, *incurvum*, Bréb.	—	×				
,, *Jenneri*, Ralfs	×					
,, *juncidum*, Ralfs	—	—	—	×		
,, *Kützingii*, Bréb.	×	—	×	—	×	
,, ,, var. *onychosporum*, W. and G. S. West (Pv)	×	—	×			
,, *Leibleinii*, Kütz	—	×	×			
,, *lineatum*, Ehrenb.	×					
,, *Lunula* (Müll.), Nitzsch.	—	×				
,, *macilentum*, Bréb.	×	×	—	×		
,, *moniliferum* (Bory), Ehrenb.	×					
,, *parvulum*, Näg.	×	—	×	—	×	
,, *pronum*, Bréb.	×	—	×			
,, *Pseudodianæ*, Roy	×	—	×			
,, *rostratum*, Ehrenb.	×					
,, *setaceum*, Ehrenb.	×	—	—	×	×	
,, ,, var. *elongatum*, W. and G. S. West (Pv)	×	—	—	—	—	×
,, *striolatum*, Ehrenb.	×					
,, *toxon*, West	×					
,, *tumidum*, Johnson	—	—	—	—	×	
,, *turgidum*, Ehrenb., forma *glabra*, Gutw.	×					
,, *Ulna*, Focke	×					
,, *Venus*, Kütz.	×					
Docidium Baculum, Bréb.	—	—	—	×		
Pleurotænium coronatum, Bréb.	×	—	—	×		
,, ,, var. *fluctuatum*, West	×					
,, *Ehrenbergii* (Ralfs), De Bary	×	—	×	×	×	
,, *nodosum* (Bail.), Lund.	—	—	—	×		
Tetmemorus Brébissonii (Menegh.), Ralfs	×					
,, *granulatus* (Bréb.), Ralfs	×	×	×	×	×	
,, *lævis* (Kütz.), Ralfs	—	×				
Euastrum affine, Ralfs	—	—	—	×		
,, *ampullaceum*, Ralfs	×					
,, *ansatum*, Raifs	×	×	×	×	×	
,, *bidentatum*, Näg.	×	×	×	×	×	
,, *binale* (Turp.), Ehrenb.	×					
,, *crassum* (Bréb.), Kütz.	×	—	—	×		
,, *denticulatum* (Kirchn.), Gay	×	×	×			
,, *Didelta* (Turp.), Ralfs	—	—	—	×		
,, *elegans* (Bréb.), Kütz.	×	×	×	×	×	
,, *gemmatum*, Ralfs	×	×				
,, *montanum*, W. and G. S. West	—	—	—	—	×	
,, *oblongum* (Grev.), Ralfs	×	×				
,, *pectinatum*, Bréb.	—	—	—	—	×	
,, ,, var. *inevolutum*, W. and G. S. West	×	×				
,, *pinnatum*, Ralfs	×					
,, *sinuosum*, Lenorm.	—	×				
,, *verrucosum*, Ehrenb.	×					

Species.	Scottish lakes.	Orkneys and Shetlands.	W. and S.W. Ireland.	Welsh lakes.	English lakes.	Lough Neagh (and L. Beg).
Euastrum verrucosum, var. *reductum*, Nordst. (p)	×	×	×	×	×	
" " var. *planctonicum*, W. and G. S. West (Pv)	×					
Micrasterias Americana, Ehrenb.	×					
" *apiculata*, Menegh., var. *fimbriata*, Ralfs	×					
" " var. *brachyptera* (Lund.), Nordst.	×					
" *conferta*, Lund.	×					
" *denticulata*, Bréb.	×	×	×	×	×	
" *Jenneri*, Ralfs	×					
" *Mahabuleshwarensis*, Hobson, var. *Wallichii* (Grun.), W. and G. S. West	×	×	—	—	×	
" *Murrayi*, W. and G. S. West (P)	×					
" " var. *triquetra*, W. and G. S. West (P)	×					
" *papillifera*, Bréb.	×	×	×	×	×	
" " var. *glabra*, Nordst.	—	—	—	×		
" *pinnatifida* (Kütz.), Ralfs	×	—	—	×	×	
" *radiata*, Hass. [= *M. furcata*, Ralfs] (p)	×	—	×	×	×	
" *rotata* (Grev.), Ralfs	×	—	—	×		
" *Sol* (Ehrenb.), Kütz. [= *M. radiosa*, Ralfs] (p)	×	×	×	×	×	
" *truncata* (Corda), Bréb.	×	—	×	×	×	
Cosmarium abbreviatum, Racib.	×	×				
" " var. *planctonicum*, W. and G. S. West (Pv)	×	—	×	×	×	
" *angulosum*, Bréb., var. *concinnum* (Rabenh.), W. and G. S. West	—	×				
" *bioculatum*, Bréb.	×	×	×	×	×	
" *Blyttii*, Wille	×	—	—	—	×	
" *Boeckii*, Wille	—	×				
" *Botrytis*, Menegh.	×	×	×	×	×	×
" " var. *tumidum*, Wolle	×					
" " var. *depressum*, W. and G. S. West (Pv)	×	—	×			
" *Brébissonii*, Menegh.	×	—	×			
" *capitulum*, Roy and Biss., var. *grœnlandicum*, Börges. (p)	×	—	×	—	×	
" *cælatum*, Ralfs	×					
" *connatum*, Bréb.	×	—	×	—	×	
" *contractum*, Kirchn.	×	—	×	×		
" " var. *ellipsoideum* (Elfv.), W. and G. S. West	×	×	×	×	×	
" *controversum*, West	×	—	—	—	×	
" *Corribense*, W. and G. S. West (P)	—	—	×	×		
" *costatum*, Nordst.	—	—	—	×	×	
" *depressum* (Näg.), Lund. [= *C. Scenedesmus*, Delp.] (p)	×	×	×	×	×	
" *depressum*, var. *achondrum* (Boldt), W. and G. S. West (p)	×	—	—	—	×	
" *difficile*, Lütkem	×					
" " var. *sublæve*, Lütkem	×	×	×	—	×	
" *exiguum*, Arch.	—	—	—	×		
" *formosulum*, Hoff.	×	×	—	—	×	
" *globosum*, Buln.	—	—	—	×		
" *granatum*, Bréb.	×	—	×			
" " var. *subgranatum*, Nordst.	—	×	—	—	—	×
" *humile*, Gay	×	×	×	×	—	×
" *impressulum*, Elfv.	×					

Species.	Scottish lakes.	Orkneys and Shetlands.	W. and S.W. Ireland.	Welsh lakes.	English lakes.	Lough Neagh (and L. Beg).
Cosmarium Kjellmanni, Wille, var. *grande*, Wille	×					
„ *Lundellii*, Delp., var. *æthiopicum*, W. and G. S. West	×					
„ *læve*, Rabenh., var. *septentrionale*, Wille	×					
„ „ forma *octangularis* (Wille) nob.	×	×	×			
„ *Logiense*, Bissett	—	—	—	—	×	
„ *margaritatum*, Roy and Bissett	×	—	—	×		
„ *margaritiferum* (Turp.), Menegh.	×	×	×	×	×	
„ *Meneghinii*, Bréb.	—	×				
„ *moniliforme* (Turp.), Ralfs	×	—	×	×		
„ *ornatum*, Ralfs	×	—	×	×	×	
„ *orthostichum*, Lund.	—	—	—	×		
„ *ovale*, Ralfs	×	—	×			
„ *Phaseolus*, Bréb.	—	×				
„ *pseudopyramidatum*, Lund.	—	—	—	×		
„ *punctulatum*, Bréb.	×	×	×	—	×	
„ „ var. *subpunctulatum* (Nordst.), Börges.	—	×	—	×		
„ *pyramidatum*, Bréb.	—	×	—	×		
„ *quadratum*, Ralfs, forma *Willei*, W. and G. S. West	—	—	—	—	×	
„ *Ralfsii*, Bréb.	×	—	—	×		
„ *reniforme* (Ralfs), Arch.	×	×	×	×	×	
„ *speciosum*, Lund.	—	×				
„ *subaversum*, Borge	×					
„ *subarctoum* (Lagerh.), Racib.	×	—	×	—	×	
„ „ forma *punctata*, W. and G. S. West	—	×				
„ *subcostatum*, Nordst.	×	×				
„ *subcrenatum*, Hantzsch.	×	×	—	—	×	
„ *subcontractum*, W. and G. S. West (P)	×					
„ *subprotumidum*, Nordst.	—	×				
„ *subtumidum*, Nordst., var. *Klebsii* (Gutw.) W. and G. S. West (p)	×	×	×	×	×	×
„ *subundulatum*, Wille	—	—	—	×		
„ *subspeciosum*, Nordst.	—	×				
„ *Turpinii*, Bréb. (p)	—	×	×	—	×	×
„ *tetraophthalmum* (Kütz.), Menegh.	×	×	×			
Cosmocladium saxonicum, De Bary	—	—	×	×		
Xanthidium antilopæum (Bréb.), Kütz.	×	—	×	×	×	×
„ „ var. *depauperatum*, W. and G. S. West (Pv)	×	×	×	×	×	
„ „ var. *Hebridarum*, W. and G. S. West (Pv)	×	—	×			
„ „ var. *læve*, Schmidle	×					
„ „ var. *polymazum*, Nordst.	×					
„ „ var. *triquetrum*, Lund. (p)	—	—	—	—	×	
„ *armatum* (Bréb.), Rabenh.	×	—	×	×	×	
„ „ var. *cervicorne*, W. and G. S. West	×	—	—	×		
„ *cristatum*, Bréb.	×	—	×			
„ „ var. *uncinatum*, Bréb.	—	—	—	—	×	
„ *fasciculatum*, Ehrenb.	×					
„ *subhastiferum*, West (p)	×	—	×			
„ „ var. *Murrayi*, W. and G. S. West (Pv)	×	—	—	—	×	
„ *controversum*, W. and G. S. West, var. *planctonicum*, W. and G. S. West (Pv)	×					

Species.	Scottish lakes.	Orkneys and Shetlands.	W. and S.W. Ireland.	Welsh lakes.	English lakes.	Lough Neagh (and L. Beg).
Xanthidium tetracentrotum, Wolle, forma, W. and G. S. West	×					
Arthrodesmus convergens, Ehrenb.	×	—	—	×	×	
„ ***crassus***, W. and G. S. West (P)	×	—	×	—	×	
„ ***Incus*** (Bréb.), Hass.	×	—	×	×	×	
„ „ var. ***longispinum***, W. and G. S. West (Pv)	×					
„ „ var. ***Ralfsii***, W. and G. S. West, forma	×	—	—	×	×	
„ ***octocornis***, Ehrenb.	×	—	—	×		
„ ***quiriferus***, W. and G. S. West (P)	×					
„ ***subulatus***, Kütz.	×					
„ ***triangularis***, Lagerh.	×	×	—	×	×	
„ „ var. ***subtriangularis*** (Borge), W. and G. S. West (Pv)	×	×	×	—	×	
Staurastrum aculeatum (Ehrenb.), Menegh.	—	—	—	×		
„ ***affine***, W. and G. S. West (P)	—	×				
„ ***alternans***, Bréb.	—	×				
„ ***anatinum***, Cooke and Wills (p)	×	×	×	×	×	×
„ „ var. ***grande***, W. and G. S. West (p)	×	—	—	×		
„ „ var. ***Lagerheimii*** (Schmidle), nob. (p)	—	—	—	—	×	
„ „ var. ***longibrachiatum***, W. and G. S. West (Pv)	×					
„ „ var. ***pelagicum***, W. and G. S. West (Pv)	×	—	—	—	—	×
„ „ var. ***truncatum***, West (p)	×	—	×	—	—	×
„ ***angulatum***, West, var. ***planctonicum***, W. and G. S. West (Pv)	×					
„ ***apiculatum***, Bréb.	—	—	×	—	—	×
„ ***Arachne***, Ralfs	×	—	×	×		
„ „ var. ***curvatum***, W. and G. S. West (Pv)	×					
„ ***Arctiscon*** (Ehrenb.), Lund. (p)	×	—	×	×	×	
„ ***aristiferum***, Ralfs	—	—	—	×		
„ „ var. ***protuberans***, W. and G. S. West (Pv)	×					
„ ***asperum***, Bréb.	×					
„ ***Avicula***, Bréb.	×					
„ „ var. ***subarcuatum*** (Wolle), West	×	—	×	×		
„ ***aversum***, Lund. (p)	×	—	×	×		
„ ***Bienianum***, Rabenh.	×	—	×			
„ ***boreale***, W. and G. S. West (P)	—	×				
„ ***brachiatum***, Ralfs	×	×	×	×	×	
„ ***Brasiliense***, Nordst., var. ***Lundellii***, W. and G. S. West (p)	×	—	×	×	×	
„ ***brevispinum***, Bréb. (p)	×	×	×	×	×	×
„ „ var. ***altum***, W. and G. S. West (Pv)	×	—	×			
„ „ var. ***obversum***, W. and G. S. West (Pv)	×					
„ ***Cerastes***, Lund.	—	—	—	×		
„ ***Clevei*** (Wittr.), Roy and Bissett	×					
„ ***conspicuum***, W. and G. S. West (P)	×					
„ ***curvatum***, West (p)	×	×	×	×	×	
„ ***cuspidatum***, Bréb.	—	—	—	—	—	×
„ „ var. ***maximum***, W. and G. S. West (p)	×	×	×	×	×	×

Species.	Scottish lakes.	Orkneys and Shetlands.	W. and S.W. Ireland.	Welsh lakes.	English lakes.	Lough Neagh (and L. Beg).
Staurastrum cuspidatum, var. *divergens*, Nordst.	×					
„ *cyrtocerum*, Bréb.	×					
„ „ var. *compactum*, W. and G. S. West (Pv)	—	×				
„ *dejectum*, Bréb. (p)	×	×	×	×	×	×
„ „ var. *inflatum*, West (p)	×	×	×	×	—	×
„ *denticulatum* (Näg.), Arch. (p)	—	—	×	×	×	
„ *Dickiei*, Ralfs	×	—	×			
„ *dilatatum*, Ehrenb., var. *obtusilobum*, De Not.	×	×	×			
„ *dorsidentiferum*, W. and G. S. West (P) ...	—	—	×			
„ *erasum*, Bréb. (p)	×	×	—	×	×	
„ *forficulatum*, Lund.	×					
„ *furcatum* (Ehrenb.), Bréb.	×	—	—	×		
„ *furcigerum*, Bréb. (p)	×	—	×	×	×	×
„ „ forma *eustephana* (Ehrenb.)	—	—	—	×	×	
„ „ forma *armigera* (Bréb.)	×					
„ „ var. *reductum*, W. and G. S. West (Pv)	—	—	×			
„ *gracile*, Ralfs	×	×	×	×	×	×
„ „ var. *nanum*, Wille	×	—	—	—	×	
„ „ var. *cyathiforme*, W. and G. S. West, forma	×	—	×			
„ *grande*, Bulnh.	×	—	×	—	×	
„ *granulosum*, Ralfs	—	—	×	—	—	×
„ „ var. *acutum* (Bréb.), W. and G. S. West	×					
„ *hexacerum* (Ehrenb.), Wittr.	—	×	×	×	×	
„ *hirsutum*, Bréb.	×					
„ *inflexum*, Bréb.	—	—	—	—	×	
„ *inelegans*, W. and G. S. West (P)	×					
„ *irregulare*, W. and G. S. West...	—	—	—	—	×	
„ *jaculiferum*, West (biradiate vertical view) (p)	×	—	—	×	×	
„ „ (triradiate vertical view) (p) ...	×	×	×	—	×	
„ „ var. *excavatum*, W. and G. S. West (Pv)	×	—	×			
„ „ var. *subexcavatum*, W. and G. S. West (Pv)	×					
„ *lævispinum*, Biss.	×					
„ *longispinum* (Bail.), Arch. (p)	×	—	×	×	×	
„ „ var. *bidentatum* (Wittr.), W. and G. S. West (p)	×	—	—	×	×	
„ *lunatum*, Ralfs, var. *planctonicum*, W. and G. S. West (Pv)	×	×	×	×	×	
„ *Maamense*, Arch.	—	—	×			
„ *Manfeldtii*, Delp. (p)	—	×	×	—	×	
„ *megacanthum*, Lund. (p)	×	—	×	×	×	
„ „ var. *Scoticum*, W. and G. S. West (Pv)	×					
„ *monticulosum*, Bréb., var. *bifarium*, Nordst.	×					
„ *mucronatum*, Ralfs, var. *subtriangulare*, W. and G. S. West (Pv)	×	—	—	×	×	
„ *muticum*, Bréb.	—	—	—	×	—	×
„ *Ophiuru*, Lund. (p)	×	—	—	—	×	
„ „ var. *cambricum*, W. and G. S. West	—	—	—	×		
„ *orbiculare*, Ralfs	×					
„ „ var. *depressum*, Roy and Bissett	—	×				

Species.	Scottish lakes.	Orkneys and Shetlands.	W. and S.W. Ireland.	Welsh lakes.	English lakes.	Lough Neagh (and L. Beg).
Staurastrum paradoxum, Meyen	×	×	×	×	×	×
„ „ var. *cingulum*, W. and G. S. West (Pv)	×	×	×	×	×	
„ „ var. *longipes*, Nordst. (p)	×	×	×	×	×	×
„ *pelagicum*, W. and G. S. West (P)	—	×	×	—	—	×
„ *pilosum*, Näg.	—	×				
„ *polymorphum*, Bréb.	×	—	—	—	×	
„ *polytrichum*, Perty	×					
„ *pseudopelagicum*, W. and G. S. West (P)	×	×	×	×	×	
„ *punctulatum*, Bréb.	×	×	—	—	×	
„ *Saxonicum*, Buln.	—	×				
„ *Sebaldi*, Reinsch., var. *productum*, W. and G. S. West (Pv)	×	—	×			
„ „ var. *ornatum*, Nordst.	—	—	×	×	—	×
„ *sexangulare* (Buln.), Rabenh. (p)	×	—	×	×	×	
„ „ var. *supernumerarium*, W. and G. S. West (Pv)	×					
„ *sibiricum*, Borge	×					
„ *sublævispinum*, W. and G. S. West	×					
„ *subnudibrachiatum*, W. and G. S. West (P)	×					
„ *subgracillimum*, W. and G. S West	×					
„ *subpygmæum*, West	×	—	×			
„ *teliferum*, Ralfs	×	×	—	×	×	
„ *tetracerum*, Ralfs	×	×	—	×		
„ *Tohopekaligense*, Wolle, var. *trifurcatum*, W. and G. S. West	×	—	×			
„ *tumidum*, Bréb.	×	—	—	×		
„ *verticillatum*, Arch.	×					
„ *vestitum*, Ralfs	—	—	—	—	×	
Spondylosium pulchrum (Bail.), Arch., var. *planum*, Wolle (p)	×	—	×	—	×	
Sphærozosma granulatum, Roy and Bissett	×	×	—	—	×	
„ *Aubertianum*, West	—	—	×			
„ „ var. *Archerii* (Gutw.), W. and G. S. West (p)	×	—	—	×	×	
„ *excavatum*, Ralfs	—	—	×			
„ *vertebratum*, Ralfs	×	—	×	×	×	
Desmidium aptogonum, Bréb.	×	—	—	×	×	
„ *coarctatum*, Nordst., var. *cambricum*, West (p)	×	—	—	×		
„ *graciliceps* (Nordst.), Lagerh.	×					
„ *occidentale*, W. and G. S. West (P)	×					
„ *Pseudostreptonema*, W. and G. S. West (p)	—	—	×			
„ *Swartzii*, Ag.	×	—	—	×	×	
Gymnozyga moniliformis, Ehrenb.	×	—	×	×	×	
„ „ var. *gracilescens*, Nordst.	×					
Hyalotheca dissiliens (Sm.), Bréb.	×	—	×	×	×	
„ „ forma *tridentula*, Nordst.	×					
„ *Indica*, Turn. (p)	×	—	×	—	×	
„ *mucosa*, Ehrenb.	×	×	×	×	×	
„ *neglecta*, Racib. (p)	×	—	×	×	×	
„ *undulata*, Nordst.	—	—	×	×		
Volvox aureus, Ehrenb.	—	—	—	×	—	×
Pleodorina californica, Shaw	×					
Eudorina elegans, Ehrenb.	×	×	×	×	×	×
Gonium pectorale, Müll.	×	—	—	×		
Pandorina Morum (Müll.), Bory.	×	×				
Chlamydomonas pulvisculus, Ehrenb.	—	—	—	—	—	×

Species.	Scottish lakes.	Orkneys and Shetlands.	W. and S.W. Ireland.	Welsh lakes.	English lakes.	Lough Neagh (and L. Beg).
Urococcus insignis, Kütz.	—	×				
Pediastrum Boryanum (Turp.), Menegh.	×	×	×	×	×	×
„ „ var. *brevicorne*, A. Br.	—	—	—	—	—	×
„ „ var. *granulatum*, Ralfs	—	×	×	—	—	×
„ „ var. *longicorne*, Reinsch.	—	—	—	—	—	×
„ *duplex*, Meyen.	×	×	×	—	—	×
„ „ var. *asperum*, A. Br.	—	—	×	—	—	×
„ „ var. *clathratum*, A. Br. (p)	—	—	—	—	—	×
„ *glanduliferum*, Benn.	—	×	—	—	×	
„ *integrum*, Näg.	—	×				
„ *simplex*, Meyen.	×					
„ *Tetras* (Ehrenb.) Ralfs	×	—	—	—	—	×
Sorastrum Americanum (Bohlin), Schmidle	×					
„ *spinulosum*, Näg.	×					
Cœlastrum cambricum, Arch. (p)	×	—	×	—	—	×
„ *microporum*, Näg.	—	—	—	×	—	×
„ *Morus*, W. and G. S. West	×					
„ *reticulatum* (Dang.), Senn. (p)	—	—	×	—	—	×
„ *sphæricum*, Näg.	×	×	×			
Crucigenia quadrata, Morren	—	—	—	—	—	×
„ *rectangularis* (Näg.), Gay	×	—	×	—	×	
„ „ forma *irregulare* (Wille)	×	×				
„ *Tetrapedia* (Kirchn.), W. and G. S. West (P)	—	—	—	—	—	×
Scenedesmus acutiformis, Schröder, var. *Brasiliensis* (Bohlin), W. and G. S. West	—	×				
„ *bijugatus* (Turp.), Kütz.	×	×	×	×		
„ „ forma *arcuatus* (Lemm.), W. and G. S. West (p)	—	—	×			
„ *denticulatus*, Lagerh., var. *linearis*, Hansg.	×	×				
„ *obliquus*, Kütz.	×	—	—	—	—	×
„ *Hystrix*, Lagerh.	×					
„ *quadricauda* (Turp.), Bréb.	×	×	×	×	—	×
„ „ var. *abundans*, Kirchn.	×	×	—	×	—	×
„ „ var. *horridus*, Kirchn.	—	—	—	—	—	×
Dimorphococcus lunatus, A. Br.	×					
Dictyocystis Hitchcockii, Lagerh.	×					
Elakatothrix gelatinosa, Wille	—	—	—	—	×	
Ankistrodesmus biplex (Reinsch.), G. S. West	—	—	×			
„ *falcatus* (Corda), Ralfs	×	×	×	×	×	×
„ „ var. *acicularis* (A. Br.), G. S. West	×	×	×	—	×	×
„ „ var. *mirabilis*, G. S. West	—	×	—	—	—	×
„ „ var. *spiralis* (Turn.), G. S. West (p)	—	×	—	—	—	×
„ „ var. *spirilliformis*, G. S. West	×	—	—	×	×	
„ *Pfitzeri* (Schröder), G. S. West (P)	×	×	×	—	×	
Closteriopsis longissima, Lemm. (p)	—	—	×	—	—	×
„ „ var. *tropicum*, W. and G. S. West	—	×				
Characium Debaryanum (Reinsch), De Toni	—	—	×			
Selenastrum gracile, Reinsch.	—	—	—	—	—	×
Kirchneriella lunaris (Kirchn.), Möb.	×					
„ *obesa*, W. and G. S. West (p)	×	×	×	—	—	×
Oocystis apiculata, West	—	×				
„ *crassa* (Wittr.)	×	×				
„ *lacustris*, Chodat (P)	—	—	×	—	×	
„ *Marssonii*, Lemm. (P)	—	—	×	—	—	×

Species.	Scottish lakes.	Orkneys and Shetlands.	W. and S.W. Ireland.	Welsh lakes.	English lakes.	Lough Neagh (and L. Beg).
Oocystis parva, W. and G. S. West (p)	×	×	—	—	×	×
„ *solitaria*, Wittr.	×	—	×	—	—	×
Nephrocytium Agardhianum, Näg.	×	×	×	×	—	×
„ *lunatum*, West (p)	×	—	×	—	×	
Tetraëdron minimum, Hansg.	—	×	—	—	—	×
„ *cruciatum* (Wolle), W. and G. S. West	×					
„ *enorme* (Ralfs), Hansg.	—	—	×			
„ *limneticum*, Borge (P)	×					
„ *regulare*, Kütz.	×					
Dictyosphærium pulchellum, Wood (p)	×	—	×	×	×	×
„ *Ehrenbergianum*, Näg.	×	×				
Botryococcus Braunii, Kütz. [inclus. *Ineffigiata neglecta*] (p)	×	×	×	×	×	×
„ *protuberans*, W. and G. S. West (P)	×					
„ *sudeticus*, Lemm.	×					
„ „ var. *planctonicus*, Lemm.	×					
Syhærocystis Schröteri, Chodat (P)	×	×	×	×	×	×
Tetraspora lacustris, Lemm. (P)	—	—	—	—	×	
Glœocystis gigas (Kütz.), Lagerh.	×	×	×	×	×	×
„ „ var. *planctonicum*, W. and G. S. West (Pv)	—	—	×			
„ *infusionum* (Schrank), W. and G. S. West	×	—	×			
„ *vesiculosa*, Näg.	×	—	×			
Golenkinia paucispinosa, W. and G. S. West (P)	—	—	—	—	—	×
Richteriella botryoides (Schmidle), Lemm., forma *quadrata* (Lemm.), Chodat (P)	—	—	×	—	—	×
HETEROKONTÆ.						
Ophiocytium cochleare, A. Br.	×					
„ *bicuspidatum*, Lemm.	×					
„ *capitatum*, Wolle	×					
Tribonema affine (Kütz.), G. S. West	×					
Askenasyella conferta, W. and G. S. West (P)	×	—	×	—	—	×
Oodesmus Dœderleinii, Schmidle (P)	—	—	—	—	—	×
Chlorobotrys regularis (West), Bohlin	—	—	×	—	—	×
BACILLARIEÆ.						
Melosira crenulata, Kütz.	—	—	×	—	—	×
„ „ var. *tenuis* (Kütz.), Grun.	—	—	—	—	—	×
„ *arenaria*, Moore	—	—	×	—	—	×
„ *granulata* (Ehrenb.), Ralfs (p)	×	×	×	×	×	×
„ *varians*, Ag.	—	—	×	—	—	×
Cyclotella compta, Kütz. (p)	×	×	×	—	×	×
„ „ var. *affinis*, Grun.	×	×	×	×	×	×
„ *Kützingiana*, Chauvin	—	—	—	—	—	×
„ *Meneghiniana*, Kütz.	×	—	×			
„ *operculata*, Kütz.	×	—	×			
„ *Schröteri*, Lemm. (P)	—	—	×			
Coscinodiscus lacustris, Grun. (p)	—	—	—	—	—	×
Stephanodiscus Astræa (Ehrenb.), Grun. (P)	—	—	—	—	—	×
Rhizosolenia eriensis, H. L. Sm. (P)	×					
„ *longiseta*, Zach. (P)	×	—	×			
„ „ var. *stagnalis*, Zach.	×					
„ *morsa*, W. and G. S. West (P)	×	—	×	—	×	
Tetracyclus lacustris, Ralfs	×	—	—	—	—	×

Species.	Scottish lakes.	Orkneys and Shetlands.	W. and S.W. Ireland.	Welsh lakes.	English lakes.	Lough Neagh (and L. Beg).
Tabellaria fenestrata (Lyngb.), Kütz.	×	×	×	×	×	
„ „ var. *asterionelloides*, Grun. (Pv)	×	×	×	×	×	×
„ *flocculosa* (Roth.), Kütz.	×	×	×	×	×	
Denticula tenuis, Kütz.	×	—	×	—	—	×
Meridion circulare, Ag.	—	—	—	—	—	×
Diatoma elongatum, Ag.	×	×	×	—	×	×
„ „ var. *tenuis* (Ag.), V. H.	—	—	—	—	—	×
Fragilaria capucina, Desmaz.	—	—	—	—	×	×
„ *construens*, Grun.	×	—	—	—	—	×
„ *Crotonensis* (A. M. Edw.), Kitton (p)	×	×	×	—	×	×
„ „ var. *contorta*, W. and G. West (Pv)	×					
„ *mutabilis* (W. Sm.), Grun.	×	×	×			
Amphipleura pellucida, Kütz.	×	×	×			
Synedra Acus (Kütz.), Grun.	×	×	—	×	×	×
„ „ var. *angustissima*, Grun.	—	—	×			
„ „ var. *delicatissima* (W. Sm.), V. H. (p)	—	—	—	—	—	×
„ *Lemmermanni*, W. and G. S. West (P)	—	—	×			
„ *pulchella*, Kütz.	×	×	×	—	×	
„ *radians* (Kütz.), Grun.	—	—	—	×	×	×
„ *Revaliensis*, Lemm.	—	—	×			
„ *Ulna* (Nitzsch), Ehrenb.	×	—	×	×	×	×
„ „ var. *longissima* (W. Sm.), Grun.	—	—	—	—	—	×
„ „ var. *splendens* (Kütz.), Grun.	—	—	—	—	—	×
Asterionella formosa, Hass. (p)	×	×	×	×	×	×
„ *gracillima*, Heib. (p)	×	—	×	—	×	×
Ceratoneis Arcus (Ehrenb.), Kütz., var. *Amphioxys* (Rabenh.), De Toni	×	—	—	—	×	
Eunotia biceps, (W. Sm.), G. S. West	×	—	—	—	×	
„ *Diadema*, Ehrenb.	×					
„ *gracilis* (Ehrenb.), Rabenh.	×	—	—	—	×	
„ *lunaris* (Ehrenb.), Grun.	×	—	×	×	×	
„ *major* (W. Sm.), Rabenh.	×	—	—	—	×	
„ *pectinalis* (Kütz.), Rabenh.	×	—	×	×	×	
„ „ var. *bidens*, Grun.	×					
„ „ var. *undulata*, Ralfs	×					
„ *tetraodon*, Ehrenb.	×					
Achnanthes coarctata, Bréb.	—	×				
„ *exilis*, Kütz.	×					
„ *flexella* (Kütz.), Bréb.	×	—	—	—	—	×
Stauroneis anceps, Ehrenb.	×					
„ *Phœnicenteron*, Ehrenb.	—	×	—	—	×	
Gomphonema acuminatum, Ehrenb.	×	—	—	×		
„ *constrictum*, Ehrenb.	×	—	—	—	×	
„ *geminatum*, Ag.	×	—	×	—	×	
„ *intricatum*, Kütz.	—	—	×	—	×	
„ „ var. *Vibrio* (Ehrenb.), V. H.	—	×				
„ *olivaceum* (Lyngb.), Kütz.	—	×	—	—	×	
Cocconeis Pediculus, Ehrenb.	—	—	—	—	—	×
„ *Placentula*, Ehrenb.	×	—	—	—	—	×
Gyrosigma attenuatum (Kütz.), Rabenh.	—	×	×	—	—	×
„ *Spencerii* (Quek.), O. K.	—	—	—	—	—	×
Navicula alpina (W. Sm.), Ralfs	×	×				
„ *Brébissonii*, Kütz.	—	×				
„ *divergens*, Ralfs	×					
„ *elliptica*, Kütz.	×	×				
„ „ var. *minima*, V. H.	×					

Species.	Scottish lakes.	Orkneys and Shetlands.	W. and S.W. Ireland.	Welsh lakes.	English lakes.	Lough Neagh (and L. Beg).
Navicula gibba, Kütz.	×	—	—	—	×	
„ *Iridis*, Ehrenb., var. *affinis* (Ehrenb.), V. H.	—	×				
„ *major*, Kütz.	×	×	×	×	×	
„ *nobilis* (Ehrenb.), Kütz.	×					
„ „ var. *Dactylus* (Ehrenb.), V. H.	×					
„ *pusilla*, W. Sm.	—	×				
„ *radiosa*, Kütz.	—	×	×	×	×	
„ *viridis*, Kütz.	—	×	—	—	×	×
Vanheurckia rhomboides, Bréb.	×					
„ „ var. *Saxonica*, W. and G. S. West	×	×	×	×	×	
Cocconema cæspitosum (Kütz.), G. S. West	—	—	×			
„ *cuspidatum* (Kütz.), G. S. West	×					
„ *Cistula*, Ehrenb., var. *maculata*, Kütz.	×					
„ *cymbiforme*, Ehrenb.	×	×	×	—	×	
„ *Ehrenbergii* (Kütz.), G. S. West	×					
„ *gastroides* (Kütz.), nob.	×					
„ *gracile* (Raben.), nob.	—	—	—	×	×	
„ *lanceolatum*, Ehrenb.	×	×	×	—	×	
„ *ventricosum* (Ag.), nob.	×	—	—	—	×	
Amphora ovalis, Kütz.	×	×	×	—	×	×
Epithemia turgida (Ehrenb.), Kütz.	×	×	×	—	×	×
Rhopalodia gibba (Kütz.), O. Müll.	×	×	—	—	—	×
Nitzschia acicularis, W. Sm.	—	—	×	—	—	×
„ *dissipata* (Kütz.), Grun., var. *acuta* V. H.	—	×				
„ *linearis* (Ag.), W. Sm.	×	×	×			
„ *Palea* (Kütz.), W. Sm.	×	×	×	—	×	×
„ *Sigma* (Kütz.), W. Sm.	—	—	—	×	×	
„ *sigmoidea* (Ehrenb.), W. Sm.	×	—	×	—	—	×
Cymatopleura elliptica (Bréb.), W. Sm.	—	×	×	—	—	×
„ „ var. *Hibernica* (W. Sm.) V. H.	—	—	—	—	—	×
„ „ var. *rhomboides*, Grun.	—	—	×			
„ *Solea*, W. Sm.	×	—	×	—	—	×
Surirella biseriata, Bréb. (p)	×	—	×	×	×	×
„ *linearis*, W. Sm.	×	×	—	—	×	
„ *ovalis*, Bréb.	×	—	—	—	—	×
„ „ var. *pinnata* (W. Sm.) V. H.	×					
„ „ var. *angusta* (Kütz.) V. H.	×					
„ „ var. *ovata* (Kütz.) V. H.	—	—	—	—	—	×
„ *robusta*, Ehrenb. (p)	×	×	×	×	×	
„ „ var. *splendida* (Ehrenb.) V. H. (p)	×	×	×	×	×	×
„ *spiralis*, Kütz.	×	—	—	—	—	×
„ *turgida*, W. Sm.	—	—	×	—	—	×
Campylodiscus Hibernicus, Ehrenb.	×	×	×	—	—	×
MYXOPHYCEÆ.						
Hapalosiphon Hibernicus, W. and G. S. West	×					
Stigonema minutum, Hass.	×	—	×			
Nostoc microscopicum, Carm.	×					
Anabæna circinalis (Kütz.), Hansg. (p)	×	×				
„ *Hassallii* (Kütz.), Wittr.	—	—	×			
„ „ var. *tenuis* (W. and G. S. West), Lemm.	—	—	×			
„ *Flos-aquæ* (Lyngb.), Bréb. (p)	×	—	×	×	×	×
„ *Lemmermanni*, P. Richter (P)	×	—	×	×	×	×
Lyngbya bipunctata, Lemm. (P)	—	—	—	—	×	

Species.	Scottish lakes.	Orkneys and Shetlands.	W. and S.W. Ireland.	Welsh lakes.	English lakes.	Lough Neagh (and L. Beg).
Lyngbya contorta, Lemm. (P)	×					
„ *Kützingii*, Schmidle, var. *distincta* (Nordst.), Lemm.	—	—	—	—	—	×
„ *limnetica*, Lemm. (P)	×	—	×	—	—	×
„ *Martensiana*, Menegh.	—	—	×			
„ *versicolor*, Gomont	×					
Oscillatoria tenuis, Ag.	×	×	×	×	×	×
„ *limosa*, Ag.	—	—	×	—	—	×
„ *Agardhii*, Gomont (p)	—	—	×	×	×	
„ *irrigua*, Kütz.	—	—	—	—	×	
„ *rubescens*, D. C. (P)	×	—	—	—	×	
Phormidium tenue (Menegh.), Gomont	—	—	×	—	—	×
Glœotrichia echinulata (Eng. Bot.), P. Richter (p)	×					
Glœothece linearis, Näg.	×	—	×			
Synechococcus major, Schroet.	×					
Merismopedia glauca (Ehrenb.), Näg.	×	×	×	×	×	
„ *æruginea*, Bréb. (p)	×	×	×	—	×	
„ *elegans*, A. Br.	—	×				
„ *punctata*, Meyen	×					
Merismopedia tenuissima, Lemm. (P)	—	—	×	×	—	×
Cœlosphærium Kützingianum, Näg. (p)	×	×	×	—	×	×
„ *minutissimum*, Lemm. (P)	×	—	×	×	—	×
„ *Nägelianum*, Unger.* (P)	×	×	×	×	—	×
„ *natans*, Lemm. (P.)	—	—	×			
Gomphosphæra aponina, Kütz.	—	—	×	—	—	×
„ *lacustris*, Chodat (P)	×	—	×	×	×	×
Aphanocapsa pulchra (Kütz.), Rabenh.	—	×				
Aphanothece saxicola, Näg.	—	—	×			
„ *clathrata*, W. and G. S. West (P)	—	—	×	—	—	×
Dactylococcopsis rhaphidioides, Hansg. (P)	—	—	×	—	—	×
Microcystis æruginosa, Kütz. (p)	—	—	×	—	×	×
„ *elabens* (Bréb.), Kütz.	×	×				
„ *icthyoblabe*, Kütz.	—	—	—	×		
„ *incerta*, Lemm. (p)	×	—	×	×	×	
„ *marginata*, Menegh.	×					
„ *Flos-aquæ* (Wittr.), Kirchn.	×	×				
„ *prasina* (Wittr.), Lemm. (p)	—	×	×	—	—	×
„ *pulverea* (Wood), Migula	—	—	—	—	×	
„ *roseo-persicina*, Kütz.	—	—	—	—	—	×
„ *stagnalis*, Lemm. (p)	×	×	×	—	×	×
Chroococcus cohærens, Näg.	×	×	×			
„ *helveticus*, Näg.	—	—	×			
„ *limneticus*, Lemm. (P)	×	×	×	×	—	×
„ „ var. *subsalsus*, Lemm. (P)	—	—	×			
„ *minimus* (v. Keissler), Lemm.	×	×	—	—	×	×
„ *pallidus*, Näg.	×	×				
„ *turgidus* (Kütz.), Näg.	×	×	×	—	×	
Phæophyceæ.						
Stichoglœa olivacea, Chodat (P)	×					
Phæococcus planctonicus, W. and G. S. West (P)	×	—	×			

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* It seems probable that this "species" is merely a form of *C. Kützingianum*, Näg.

Species.	Scottish lakes.	Orkneys and Shetlands.	W. and S.W. Ireland.	Welsh lakes.	English lakes.	Lough Neagh (and L. Beg).
FLAGELLATA.						
Dinobryon bavaricum, Imhof. (p)	×	—	×			
„ *cylindricum*, Imhof. (p.)	—	—	×	×	×	
„ „ var. *pediforme*, Lemm.	×	—	—	×		
„ „ var. *palustre*, Lemm.	×	—	×			
„ „ var. *angulatum*, Lemm. (p)	×					
„ „ var. *divergens* (Imhof.), Lemm. (p)	×	×	×	×	×	×
„ „ var. *Schauinslandii*, Lemm. (p)	×	—	×			
„ *elongatum*, Imhof. (p)	×	—	×	×	×	
„ „ var. *undulatum*, Lemm. (p)	×	×	×	×	×	
„ *protuberans*, Lemm. (p)	×	—	—	×	—	×
„ *Sertularia*, Ehrenb.	×					
„ „ var. *thyrsoideum* (Chodat), Lemm. (p)	—	—	×	—	—	×
„ *sociale*, Ehrenb.	—	—	×			
„ *utriculus* (Ehrenb.), Klebs.	×					
Halobryon Lauterbornii, Lemm. (p)	×					
Synura uvella, Ehrenb.	—	—	—	—	×	
Mallomonas acaroides, Perty (p)	×	×	×			
„ *caudata*, Iwanoff	×	—	×			
„ *producta*, Iwanoff	—	—	×			
„ *longiseta*, Lemm. (P)	×	—	—	—	×	
Diplosigopsis frequentissima, Lemm. (p)	×	—	×	×		
Bicœca lacustris, J. Cl., var. *longipes*, Zach. (p)	—	—	×	×		
Cryptomonas erosa, Ehrenb.	—	—	×			
Lepocinclis ovum (Ehrenb.), Lemm., var. *punctato-striatum*, Lemm.	—	—	×			
Euglena viridis, Ehrenb.	×	×	×	×		
PERIDINIEÆ.						
Gymnodinium, sp.	—	—	×			
„ *paradoxum*, Schilling (p)	×	—	—	—	×	
„ „ var. *major*, Lemm. (Pv)	—	—	×			
Glenodinium pulvisculus (Ehrenb.), Stein (p)	×	—	×	—	—	×
Ceratium cornutum (Ehrenb.), Clap. and Lachm. (p)	×	×	×	×	×	
„ *curvirostre*, Huitf.-Kaas. (P)	×					
„ *hirundinella*, O. F. Müller (P)	×	×	×	×	×	×
Peridinium bipes, Stein	—	—	×			
„ *cinctum*, Ehrenb. (p)	—	—	×	—	—	×
„ *inconspicuum*, Lemm.	×	—	—	×	×	
„ *limbatum* (Stokes), Lemm. (p)	—	—	×			
„ *pusillum*, Schilling (p)	×					
„ *tabulatum* (Ehrenb.), Clap. and Lachm.	×	×	×	×	×	×
„ *umbonatum*, Stein	×					
„ *Westii*, Lemm. (P)	×					
„ *Willei*, Huitf.-Kaas. (P)	×	×	×	×	×	×

The above list includes the species of the lake-plankton only, and the Flagellata are very incompletely recorded.

Were the species of the helioplankton of large ponds, pools, and ditches also included, many of the Protococcaceæ (or Autosporaceæ) would have to be added, such as sundry species of *Chodatella*, *Lagerheimia*, *Golenkinia*, and other genera.

The following summary is instructive:—

	Species only.						Totals. Species and varieties of each group.	
	Scottish.	Orkneys and Shetlands.	W. and S.W. Ireland.	Welsh.	English lakes.	Lough Neagh (and L. Beg).	Species.	Varieties.
Chlorophyceæ (except Desmidiaceæ)	54	31	37	20	24	33	81	18
Desmidiaceæ	176	85	103	101	96	22	236	68
Heterokontæ	5	—	2	—	—	3	7	0
Bacillarieæ	63	37	47	18	41	41	94	22
Myxophyceæ	31	17	33	12	17	21	53	2
Phæophyceæ	2	—	1	—	—	—	2	0
Flagellata (except Peridinieæ)	12	4	13	6	4	3	18	7
Peridinieæ	11	4	10	5	6	5	15	1
Totals of species for each area, and grand total of both species and varieties for entire British phytoplankton	354	178	246	162	188	128	506 Grand total.	118

The grand total of 506 species and 118 varieties is sufficient evidence in itself that the British phytoplankton is exceedingly rich, and of this total 46 per cent. are species of the Desmidiaceæ.

Many of these constituents are, of course, adventitious or casual, consisting of littoral or bog species which are carried into the plankton by the rains and exist there only a short time before perishing. There are, however, many constituents which are exclusively limnetic in habit, and also others which are much more abundant in the plankton than in other situations. These have been discriminated in the foregoing list.

XI. General Summary and Discussion on the Dominance of Desmids.

The tabulated list gives a very adequate idea of the Algal constituents of the British freshwater plankton, and also shows that many of these constituents are common to the four British lake-areas.

The British lakes combine to some extent the characteristic features of the Central European and Northern European lakes, but are on the whole more nearly akin to the latter. In addition they have peculiarities which tend to mark them off from either of those groups; for instance, the relatively high winter temperatures. Very many of these lakes never freeze, and most of the others only rarely become covered with ice, and then for comparatively brief periods. The summer temperatures are also comparatively low. The highest temperature we have recorded in Windermere in the course of twelve months' observations (including one of our warmest summers) was 14°·4 C. (58° F.), in Wastwater 17°·2 C. (63° F.), and in Ennerdale Water 15°·5 C. (60° F.). The highest temperatures we have obtained in the Welsh lakes were 17°·5 C. (63°·5 F.) in Llyn Ogwen and 18° C. (64°·5 F.) in Llyn Llydaw. The small sheet of water known as Llyn Elsie attained a summer (August) temperature of 19°·7 C. (67°·5 F.). The summer temperature of the Irish lakes rarely exceeds 18°·3 C. (65° F.). The average range of temperature in the Scottish lochs is from about 5° C. to 13° C., and the highest we have ourselves measured was 16°·6 C. (62° F.) in Loch Earn.

In all the four British lake-areas the water is soft, with only small quantities of dissolved lime, a peculiarity which accounts for the rarity of snails at the lake margins.

The phytoplankton is never of very great bulk, and it is quite exceptional for it to colour the water to any appreciable extent.

The periodicity of the phytoplankton is very variable in the different lakes. In some it is conspicuous, but in others it is not very well marked. Investigations at present in progress indicate that it is most conspicuous in the shallower lakes, and particularly in those at considerable altitudes, but at present our data are not nearly sufficient for generalisations to be made.

The MYXOPHYCEÆ play quite a secondary part in the plankton of the British lakes as compared with the Central European lakes. They are more abundant in some of the Irish lakes than in any of the others, and sometimes the phenomenon of "water-bloom" makes its appearance. This phenomenon, which is due to sudden and simultaneous maxima of a few of the limnetic species of Blue-green Algæ, is of very irregular occurrence in the British lakes, and is practically confined to sporadic appearances in some of the shallower-lakes.*

Oscillatoria tenuis is general but never abundant, and *Anabæna Lemmermanni* should be specially mentioned, as its spores form deep blue-green floating clusters, which sometimes give a decided colour to the surface water.

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* The phenomenon of "water-bloom" is better seen in some of the large pools and meres of the lowland parts of Britain than in any of the lake-areas. A good description of the "breaking of the meres" has been given by Phillips in 'Trans. Shropshire Archæol. and Nat. Hist. Soc.,' 1883, and earlier records were by Greville, Dickie, and Drummond.

Of the colonial unicells, *Cœlosphærium Kützingianum* (and the form of it known as *C. Nägelianum*), *Gomphosphæria lacustris*, and *Chroococcus limneticus* are the most important. *Microcystis* (*Clathrocystis*) *æruginosa* occurs more particularly in pools and small, shallow lakes, where the temperature of the surface water becomes relatively high in the summer.

In the Scottish and the Welsh lakes the Blue-green Algæ are decidedly scarce. This scarcity is to be attributed to the Alpine character of so many of these lakes, in which the maximum temperature of the surface water is relatively low.

The FLAGELLATA are well represented by various Peridinieæ, by *Mallomonas*, and by several species of *Dinobryon*. In many of the larger British lakes *Dinobryon* completely dominates the spring plankton, and a few colonies generally persist through the summer and the early part of the autumn. The most abundant species is *D. cylindricum*, and its var. *divergens* is equally common. In the smaller lakes *Dinobryon* is fairly general, but does not attain such great maxima as in the larger lakes. *Mallomonas acaroides* sometimes occurs in prodigious abundance, but lasts only a few weeks.

Of the Peridinieæ, *Ceratium hirundinella* is general, but it only occurs in large maxima in the smaller lakes. The variations in this organism have been well described and figured,* but there is one form in the lakes of the Outer Hebrides and the west of Ireland† which is apparently unknown in the plankton of the rest of Europe. In this curious form the first antapical horn is very much deflected to one side (*vide* fig. 3). Species of *Peridinium* often occur in very large quantity in the smaller lakes, and in the shallower of the large lakes. *P. tabulatum* is frequent, but *P. Willei* is general throughout the Scottish, Irish, and English lakes.‡ It occurs most abundantly in the small upland lakes (up to 1800 feet) with an Alpine character. *P. Westii* is exclusively confined to the Scottish lakes, where it appears to be frequent.

The BACILLARIEÆ are abundant in the British phytoplankton, but they rarely occur in such great quantities as in the Central European lakes, and scarcely ever form the vast maxima which periodically appear in so many of those lakes. Diatoms are fewest in the plankton of the Welsh lakes, forming only an average of 11 per cent. of the entire phytoplankton. This low percentage is probably due to the small numbers of adventitious species washed into the lakes from the mountain sides, and is possibly accentuated by the stony character of the lake margins and lake bottoms. They occur in the greatest variety in the Scottish and Irish lakes, probably owing to the large number of adventitious species washed into the lakes by the rains. The Pennate Diatoms are much the most numerous and conspicuous.

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* Lemmermann, in 'Archiv för Bot. utgifv. af K. Sv. Vet.-Akad.,' Bd. 2, 1904, No. 2, t. 2, f. 1—49; W. and G. S. West, in 'Roy. Soc. Edin. Trans.,' vol. 41, 1905, p. 494 (*c.* fig.); 'Roy. Irish Acad. Trans.,' vol. 33, sect. B, part 2, 1906, pp. 93, 94 (*c.* figs. 1—9); Bachmann in 'Archiv für Hydrobiologie und Planktonkunde,' Bd. 3, 1907, pp. 55—58, figs. I, I*a*, II.

† W. and G. S. West, in 'Roy. Irish Acad. Trans.,' *loc. cit.*, 1906, p. 94, f. 9.

‡ The distribution of *Peridinium Willei*, Huitf.-Kaas, extends from N. Italy, Ireland, England, and Scotland to Norway, Finland, the Faeroes, and Iceland.

Among the commonest forms are *Asterionella* (with a range of form and size which embraces both *A. formosa* and *A. gracillima*) and the two species of *Tabellaria*. *T. fenestrata* is much more abundant than *T. flocculosa*, except in the English lakes, where the reverse obtains. The chain-forms of *T. fenestrata* are the most frequently observed, but the star-dispositions (var. *asterionelloides*) are common except in the Welsh lakes. *T. fenestrata*, var. *asterionelloides*, is one of the dominating features of the late spring, the summer, and the early autumn plankton of many British lakes, and it exhibits great variability in the relative strength and breadth of the girdle view of the cells.* That these differences are of no varietal importance is proved by the occurrence of all intermediate stages.

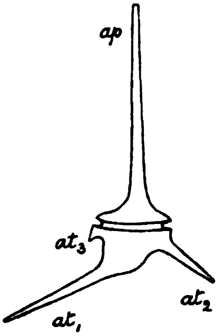

FIG. 3.—Peculiar Form of *Ceratium hirundinella*, O. F. M., in which the first antapical horn (at_1) is greatly deflected to one side. × 200.

We have not observed any star-dispositions of *T. flocculosa* in any of the British lakes, although such have been observed by Holmboe in Norway and by Wesenberg-Lund in Denmark (*T. flocculosa*, var. *pelagica*, Holmboe).

The numerous plankton-forms of *Asterionella* almost convince one that *A. formosa* and *A. gracillima* are merely states of the same species. No chains of *Asterionella* were observed in any of the lakes.

The genus *Fragilaria* is somewhat rare, and of the species which occur *F. capucina* is the commonest. *F. crotonensis* is very general in Scotland

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* *Cf.* W. and G. S. West, in 'Roy. Soc. Edin. Trans.,' vol. 41, 1905, Plate 2, figs. 1—3.

and Ireland, but is always scarce. We have not observed it in the English* or Welsh lakes. A variety of it—var. *contorta*—occurs in Loch Ruar, Sutherland, which is unique in the curious twisting of its exceedingly short filaments. This variety is not known from elsewhere.

Throughout all the British lake-areas, but more especially in the west of Scotland and the west of Ireland, species of the genus *Surirella* form a considerable and conspicuous part of the phytoplankton. The most frequent is *Surirella robusta*, var. *splendida*, which sometimes occurs in great abundance,† but *S. biseriata* and *S. linearis* are both general. In this respect the British lakes compare with the lakes of Central Africa, in which several plankton-species of *Surirella* are abundant.‡ In the Yan Yean Reservoir, Victoria, *S. robusta*, var. *splendida*, is also a constituent of the plankton.§ Wesenberg-Lund‖ states that various species of the genera *Surirella* and *Cymatopleura* occur in the plankton of principally alpine or shallow lakes in level country, and that they have been carried out by rivers and waves into the pelagic region, where they vegetate but for a short period and then perish. We find that in the British lakes, and also in those of Central Africa, the genus *Surirella* is frequently a true plankton-genus, and the various species which have been recorded both vegetate and multiply in the plankton to an extent we have rarely noticed in other situations.

Several of the Naviculaceæ occur with considerable regularity.

Centric Diatoms are relatively few and insignificant in the British lakes. *Melosira* is represented chiefly by *M. granulata* and *M. varians*. The latter is perennial in the plankton of British rivers. Species of *Cyclotella* are not abundant, and only in Lough Corrib, Galway, have we observed the curious gelatinous colonies which occur so frequently in some of the Central European lakes.

The genus *Rhizosolenia* is represented by two (and if the record of *R. eriensis* be correct, by three) species. *R. longiseta* is very rare, but *R. morsa* occurs in some of the lakes of all the British lake-areas. We have observed the resting-spores of this species in the June plankton of Thirlmere in the English Lake District.

No species of *Attheya* has yet been observed in any of the British lakes.

The CHLOROPHYCEÆ are well represented in the British lakes, more especially by the Desmidiaceæ. Apart from the latter, *Botryococcus Braunii* and *Sphærocystis Schroeteri* are the most general and abundant. Species of *Oocystis* are frequent, but never occur in quantity. *Dictyosphærium pulchellum* often occurs abundantly, but it also at times occurs in equal abundance in bogs.

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* This species occurs both in the plankton (helioplankton) and the benthos of the large pools in the Midlands of England.

† Consult W. and G. S. West, *loc. cit.*, Plate 1, figs. 1—4, and Plate 2, fig. 6 (photos).

‡ G. S. West, in 'Linn. Soc. Bot. Journ.,' vol. 38, 1907, p. 85.

§ G. S. West, in 'Linn. Soc. Bot. Journ.,' vol. 39, 1909, p. 17.

‖ Wesenberg-Lund, 'Plankton Investigations of the Danish Lakes,' Copenhagen, 1908, p. 42.

Eudorina elegans is fairly general, even in large lakes such as Lough Corrib, although it reaches its maximum abundance in small lakes.

Pediastrum Boryanum and *P. duplex* are frequent in the plankton of the shallower lakes, but *P. simplex* is very rare. Several species of *Cœlastrum*, *Scenedesmus*, and *Crucigenia* occur in many of the lakes, but never in quantity.

Species of *Zygnema*, *Spirogyra*, and *Mougeotia* occur in the plankton of most of the lakes, principally in the late spring and summer. They are usually the slender species of these genera, and are almost invariably sterile. In the smaller alpine lakes *Mougeotia* is often abundant, and forms no small part of the phytoplankton.* The curious coiled *Mougeotia*-filaments of some of the Scottish lochs have already been referred to. It would appear that the coiling is a limnetic character,† developed to augment the floating-capacity of the filament, and the fact of its presence is direct evidence that some of these solitary filaments of *Mougeotia* are adapting themselves to a life in the plankton.

THE MOST INTERESTING FEATURE OF THE BRITISH FRESHWATER PHYTOPLANKTON IS THE DOMINANCE OF DESMIDS. In 1903, and again in 1905, we showed that in contrast to any previously known plankton that of the Scottish lakes was unique in the abundance of its Desmids. Since then we have found that this dominance of Desmids is not confined to the lochs of the Scottish Highlands, but is a feature of the plankton of the four lake-areas of the British Islands, and that *the plankton of the western British lake-areas differs markedly from all other European plankton in the abundance of its Desmids.*‡

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* In the alpine lakes of the Pike's Peak Region, Colorado, Shantz states that species of *Spirogyra* and *Œdogonium* form a large part of the summer plankton (*vide* 'Amer. Microscop. Soc. Trans.,' March, 1907). Fragmentary filaments of various species of *Œdogonium* are also very frequent in the summer plankton of the British lakes.

† Consult G. S. West in 'Linn. Soc. Bot. Journ.,' vol. 38, 1907, pp. 85 and 86.

‡ Among European lakes, only those of Norway and certain parts of Sweden approach the British lakes in the possession of a conspicuous Desmid-flora in the plankton (consult Huitfeldt-Kaas, *loc. cit.*, 1906; and Lemmermann, in 'Archiv för Bot. utgiv. af K. Sv. Vet.-Akad.,' Bd. 2, 1904), and it should be mentioned that many of these plankton Desmids are identical with the British ones. Tanner-Fullemann has recorded the occurrence of a number of Desmids in the plankton of the Schoenenbodensee (*vide* 'Bull. de l'Herb. Boissier, 2me sér., t. 7, 1907), but the species which he records, when it is

In discussing this phenomenon of the rich Desmid-flora of the British freshwater plankton, it is necessary, in the first place, to briefly outline the general distribution of the Desmidiaceæ in the British Islands, *quite irrespective of the freshwater plankton.* We have studied the distribution of British Desmids in detail during the past 16 years, and the obvious fact, patent to anyone who chooses to collect these plants over extensive areas, is the *much greater richness of the Desmid-flora in the western areas of the country.* The eastern districts of England are exceedingly poor, but on passing from the newer Tertiary formations to the Older Palæozoic and Precambrian formations the Desmid-flora gradually increases in richness, attaining its maximum diversity in certain of the Precambrian areas.

The richest areas of all are the little boggy pools and smaller lakes of the Lewisian Gneiss of North-west Scotland and the Outer Hebrides, and similar areas on the Precambrian formations of Donegal, Mayo, and Galway. There are also several very rich localities in the English Lake District and North Wales, all on the Silurian and Ordovician with sundry Igneous intrusions. There are, in addition, two rich localities in the south of England, one on the Lower Greensand of Surrey (Thursley Common), and the other on the Middle Eocene of Hampshire (the New Forest). In both these localities there are deep, spongy bogs, with a fairly rich Desmid-flora, but at the same time it is a flora which falls far short of the much richer Desmid-floras of the Precambrian areas. We may add that these are not statements based upon a few casual observations, but upon a detailed examination of many thousands of collections made in all parts of the country, from the Shetland to the Scilly Islands, and from the east of England to the west of Ireland. It is also necessary to give some explanation of what is meant by a "rich" area. We do not apply the term "rich" to a mere abundance of Desmids, or even to the occurrence of a great quantity of 30 or 40 species, but only to those areas in which 150 to 200 (or even 300) species can be found in more or less abundance, including many of the rare species with a restricted distribution.

We have, therefore, as a foundation on which to base this discussion of

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possible to be certain of his identifications, are those of shallow alpine and subalpine lakes, and not in any way comparable to the characteristic plankton species of the western British areas. Neither do we regard his records as constituting a "rich" Desmid-flora.

Among extra-European lakes, Victoria Nyanza has a conspicuous Desmid-flora in the plankton, and the Yan Yean Reservoir, Victoria, possesses a very rich Desmid-plankton, quite equal to the best of the British lakes, although with an entirely different association of species. In the latter case the drainage water is mostly from Silurian and Granitic outcrops, but it is not yet possible to make a definite statement concerning the drainage into Victoria Nyanza.

the dominance of Desmids in the plankton of the British lakes, a fairly complete and necessary knowledge of the general distribution of Desmids in the bogs, pools, etc., throughout the whole of the British Islands. The first point of importance is that the great majority of the British lakes (those constituting the western and north-western lake-areas) are all situated in the richest Desmid-areas in these Islands, or for that matter in Europe. It is, therefore, not in the least surprising that the plankton of these lakes should on the whole contain an abundance of Desmids. That the Desmids of the plankton should differ considerably from those of the bogs of the drainage areas—a matter discussed in a later part of this paper—does not affect the main question, *viz.*, *that the phytoplankton of these lakes possesses in many instances such an abundance of Desmids that it can be correctly described as a Desmid-plankton.*

Those facts which explain the abundance of Desmids in the bogs and bog-pools, among the mosses of the dripping rocks, and among the leaves of the submerged plants of the lake-margins, will likewise furnish the explanation of the abundance of Desmids in the plankton, as the plankton-Desmids have certainly originated from bog and swamp species, and others are being constantly recruited from the same sources. In endeavouring to discover the relationship between the conditions of environment and the richness of the Desmid-flora, two facts stand out very clearly :—

1. The rich Desmid-areas correspond very accurately with the areas of the old geological formations. They are mostly mountainous districts, with considerable outcrops of Igneous rocks.

2. These areas also correspond, but with less accuracy, to the areas of greatest rainfall.*

It is now necessary to enquire more closely into the relationships between the geological nature of the drainage-area, the rainfall, and the richness of the Desmid-flora.

We will first consider the *rainfall* of the areas in question. This is relatively heavy, varying from about 45 to upwards of 100 inches, and is due to two causes: first, to the fact that these areas are almost all near the west coast, being districts in which large mountains are situated in close proximity to the sea; and secondly, to the prevailing westerly and south-westerly winds. Such conditions naturally result in wet, mossy hill-sides, with numerous bogs. There is consequently much peaty water, rich in humic and other organic acids, in which submerged plants, such as *Utricularia minor*, *Sphagnum cuspidatum*, *S. subsecundum*, and other

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* Mr. James Murray (in 'Roy. Phys. Soc. Edin. Proc.,' vol. 16, 1905, p. 58) also points out that Sir John Murray had indicated this fact to him.

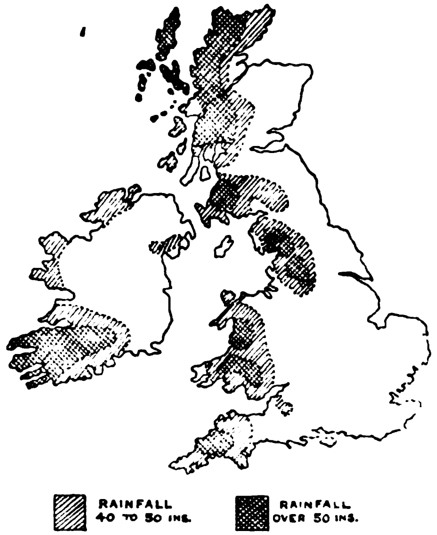

Fig. 4.

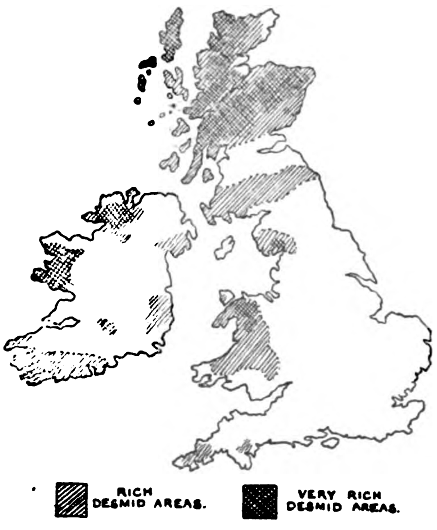

Fig. 5.

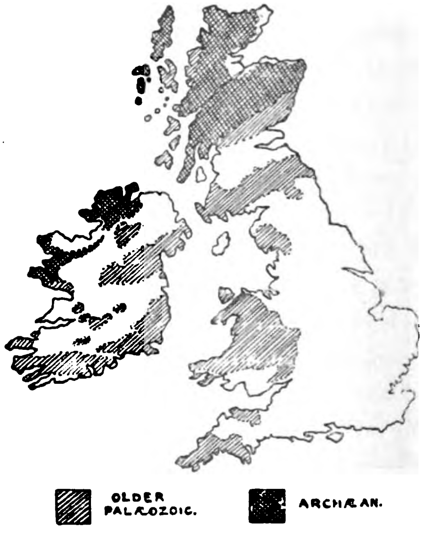

Fig. 6.

Maps of British Islands, to show (fig. 4) areas with Rainfall over 40 inches ; fig. 5, distribution of rich and very rich Desmid-areas, characterised by the western types mentioned (pp. 201 and 202); fig. 6, distribution of Older Palæozoic and Archæan rocks.

Note.—The Desmid-flora of the central and south-eastern counties of Ireland is very imperfectly known. Notice the falling off in the Desmid-flora of Skye in fig. 5, corresponding with the absence of Archæan rocks indicated in fig. 6.

aquatics thrive, and furnish all the requirements for the prolific growth of Desmids.

This seems a natural explanation of the occurrence of a rich Desmid-flora, and one which is accepted by Wesenberg-Lund* as the main cause of the phenomenon.

A detailed study of the distribution of Desmids has shown us, however, that the mere presence of suitable habitats is insufficient to account for the great richness of the Desmidiaceæ in certain areas of these Islands. Among the mountains of the Pennine Chain are some of the finest peat-bogs in the British Islands—in all outward appearances ideal spots for the occurrence of a rich Desmid-flora. Such are Cocket Moss, Austwick Moss, and others less well known. Again, on Thursley Common in Surrey, and in the New Forest, are bogs which are unsurpassed in Britain as habitats for the Desmidiaceæ. In all these localities the bogs are deep and dangerous, fed mostly by bottom springs, and furnish an ideal home for quantities of submerged *Sphagnum* and *Utricularia minor.* Desmids occur in countless millions among the larger aquatics; in fact, collections made in these localities would be regarded as "rich" or "very rich" by those who had no experience of the western areas. *Utricularia minor,* which harbours some of the best of British Desmids among its leaves, flowers profusely in the localities mentioned, and no finer specimens can be obtained even in Mayo and Galway. Yet the Desmid-flora which occurs among the *Utricularia* in the above-mentioned localities is not to be compared with that which occurs in precisely the same environment in the western British areas, and, moreover, it contains none of the real British rarities.

How is it that an ideal locality such as Cocket Moss, which would be described as "rich in Desmids," contains practically none of those species which are both dominant and characteristic of the western areas? The conditions are almost identical with those obtaining in the western bogs, and the rainfall is from 50 to 60 inches.

From a consideration of the above remarks it is obvious that some factor, other than mere abundance of rainfall and presence of ideal habitats, has a profound influence on the distribution of Desmids. This at once causes us to enquire into the statement that we have previously made,† viz., that *the rich Desmid-areas correspond geographically with the Precambrian and Older Palæozoic outcrops* (*together with the intrusive Igneous material*). (Consult figs. 5 and 6.)

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* Wesenberg-Lund, 'Plankton Investigations of the Danish Lakes,' Copenhagen, 1908 p. 281.

† *Vide* p. 197 of the present paper.

In the first place, it has been recently pointed out[*] that the association of the rich Desmid-areas with the older strata is (in the British Islands) most probably due in part to the antiquity and consequent hardness of the rocks. The mountainous regions which have resulted from those changes in the earth's surface which have produced folding and contortion, and from the resistance of these old, compressed rocks to subaerial denudation, are not only directly responsible for the rainfall owing to their geographical position, but are themselves most suitable for the formation of peat-bogs. In these areas Desmids flourish, and therefore, so far as the British Islands are concerned, the richness of the Desmid-flora bears a distinct relationship to the antiquity of the geological formations of any area under consideration. It seems probable that the determining factor is a chemical one. It is certainly something more than mere suitability of habitat, otherwise how is the relative poorness of the extensive bogs of the more recent formations to be explained ?[†]

It is very probable that the chemical composition of the water plays an important part in determining this distribution. That the chemical factors are quite apart from the occurrence of brown, peaty water, is evident from the poorness of the Desmid-flora of so many peat-bogs, and also from the fact that the best and richest Desmid-floras only occur in clear water with no obvious peaty characters. Wesenberg-Lund is incorrect when he states that Desmids *chiefly* thrive in "brown water rich in humic acids."[‡] Some of them certainly do, and often profusely, but these are generally the common, ubiquitous species which have almost a world-wide distribution. The great majority, including most of the western British types, prefer clear water with little peat. An excess of the brown peaty material is distinctly unfavourable. The plankton-Desmids also occur much more abundantly in the clear lakes than in the brown peaty ones.

Although it appears so probable that chemical factors determine the distribution of many Desmids, no definite information on this point has yet been obtained. The drainage water which has percolated through the old formations (rocks and soil) may possibly contain minute quantities of something in solution which greatly favours the development of certain types of Desmids, and may be directly responsible for their restricted distribution.[§]

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[*] G. S. West, in 'Linn. Soc. Bot. Journ.,' 1909, vol. 39, p. 10.

[†] How is it, also, that the peaty bogs and ditches of the fens of the east of England, such as are left of them, are poorer in the Desmidiaceæ than any other part of the British Islands?

[‡] Wesenberg-Lund, *loc. cit.*, 1908, pp. 280 and 281.

[§] There would be nothing remarkable in this, as diatoms thrive and build up their siliceous cell-walls in water containing silica in such minute quantities that ordinary chemical analysis reveals no trace of it.

In reference to the above remarks, James Murray* has stated that "another theory is that the lochs which are richest in Desmids are only found in the older geological formations, but this does not accord with facts, as I find that such lochs occur in all the formations from the Lewisian to the Tertiary, at least; and it will, I think, be found that some of these lochs lie entirely in glacial deposits." It should be pointed out that if glacial drift is excluded none of the lake-areas are even near the British Tertiary formations. Many of the lakes have doubtless been formed in Tertiary times, and if they are spoken of as "Tertiary lakes" it must be distinctly understood that *they are situated in drainage-basins on the old formations.* Those lakes which Murray has termed "Tertiary lakes" are certain of the Scottish lochs which are surrounded by and rest upon more or less extensive sheets of glacial drift. It must be distinctly borne in mind that most of this glacial drift has been derived from the old rocks, and what is very much more important, that the drainage into such lakes consists mostly of water which has partly traversed the exposed outcrops of the old rocks of the surrounding hills and mountains, and partly percolated through them. Therefore, any peculiarities which may be characteristic of the drainage water from the old formations, are also equally characteristic of the water of such lakes.

The point of primary importance is that the greater part of the drainage water of such a lake has traversed the older rocks, and possesses those peculiarities which so far as we can see account for the Desmid-flora not only of its plankton, but of its littoral region and also of the surrounding bogs. It is immaterial *when* the lake was formed, or whether its bed be one of glacial drift or of old rocks.

IN THE BRITISH ISLANDS THE REALLY RICH DESMID-FLORAS, CONTAINING MANY OF THE WESTERN BRITISH TYPES, ARE ONLY FOUND IN THOSE AREAS WHICH COMBINE THE MOST SUITABLE HABITATS (*such as are found on boggy hill-sides with an abundant rainfall*) WITH A DRAINAGE-WATER DERIVED FROM GEOLOGICAL FORMATIONS OLDER THAN THE CARBONIFEROUS.

We would suggest a very exact chemical investigation of the water of bogs and lakes in different areas as a possible means of throwing further light upon this question. It has been suggested that the absence of lime is the determining factor in the abundance of Desmids, and it may possibly have much to do with the restricted distribution of the western British types.

There are a large number of western types of British Desmids, of which the most important are included in the following list:—

Gonatozygon aculeatum, Hastings; *Spirotænia trabeculata*, A. Br.; *Penium*

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* James Murray, *loc. cit.*, 1905, p. 58.

adelochondrum, Elfv.; *P. Clevei*, Lund.; *Tetmemorus Brébissonii* (Menegh.), Ralfs, var. *minor* De Bary.

Micrasterias radiata, Hass.; *M. conferta*, Lund.; *M. pinnatifida* (Kütz.), Ralfs; *M. apiculata* (Ehrenb.), Menegh., and var. *brachyptera* (Lund.), W. and G. S. West.

Euastrum pictum, Börges. forma; *E. Turneri*, West; *E. aboense*, Elfv.; *E. intermedium*, Cleve; *E. pingue*, Elfv.; *E. validum*, W. and G. S. West.

Docidium undulatum, Bail.; *Pleurotænium eugeneum* (Turn.), W. and G. S. West.

Cosmarium bipunctatum, Börges.; *C. capitulum*, Roy and Biss., var. *grœnlandicum*, Börges.; *C. Corribense*, W. and G. S. West; *C. commissurale*, Bréb., var. *crassum*, Nordst., *C. distichum*, Nordst.; *C. didymoprotupsum*, W. and G. S. West; *C. entochondrum*, W. and G. S. West; *C. monomazum*, Lund., var. *polymazum*, Nordst.; *C. obsoletum* (Hantzsch), Reinsch; *C. perforatum*, Lund.; *C. pseudexiguum*, Racib.; *C. pseudopyramidatum*, Lund., var. *stenonotum*, Nordst.; *C. quadridentatum*, W. and G. S. West; *C. quadrifarium*, Lund.; *C. retusum* (Perty), Rabenh.; *C. retusiforme* (Wille), Gutw.; *C. Smolandicum*, Lund., var. *angustatum*, West; *C. sexnotatum*, Gutw., var. *tristriatum* (Lütkem.), Schmidle; *C. subquadrans*, W. and G. S. West; *C. subretusiforme*, W. and G. S. West; *C. synthlibomenum*, West; *C. taxichondriforme*, Eichl. and Gutw.; *C. tenue*, Arch.; *C. tumidum*, Lund.; *C. venustum*, Bréb., var. *hypohexagonum*, West; *C. viride* (Corda), Josh.; *C. zonatum*, Lund.

Staurastrum Arctiscon (Ehrenb.), Lund.; *St. aversum*, Lund.; *St. bacillare*, Bréb.; *St. Brébissonii*, Arch.; *St. Brasiliense*, Nordst., var. *Lundellii*, W. and G. S. West; *St. Cerastes*, Lund.; *St. Clevei* (Wittr.), Roy and Biss.; *St. conspicuum*, W. and G. S. West; *St. corniculatum*, Lund.; *St. curvatum*, West; *St. dorsidentiferum*, W. and G. S. West; *St. elongatum*, Barker; *St. erasum*, Bréb.; *St. forficulatum*, Lund.; *St. grande*, Bulnh.; *St. lævispinum*, Biss.; *St. longispinum* (Bail.), Arch.; *St. maamense*, Arch.; *St. megalonotum*, Nordst.; *St. natator*, West; *St. Ophiura*, Lund.; *St. Picum*, W. and G. S. West; *St. quadrangulare*, Bréb.; *St. setigerum*, Cleve; *St. sexangulare* (Bulnh.), Rabenh.; *St. spiniferum*, West; *St. subgracillimum*, W. and G. S. West; *St. cosmospinosum* (Börges.), W. and G. S. West; *St. Duacense*, W. and G. S. West; *St. Hibernicum*, West; *St. jaculiferum*, West; *St. cornutum*, Arch.

In addition to the above, there are a number of species which are extremely rare in a few of the richest localities outside the western areas, whereas in the latter they are generally distributed and many of them prodigiously abundant. Such are:—

Spirotænia acuta, Hilse; *Netrium oblongum* (De Bary), Lütkem., var.

cylindricum, W. and G. S. West; *Penium exiguum*, West; *Closterium Ulna*, Focke; *Tetmemorus minutus*, De Bary; *Micrasterias Sol*, Ehrenb.

Euastrum crassum (Bréb.), Kütz., var. *scrobiculatum*, Lund.; *E. crispulum* (Nordst.), W. and G. S. West; *E. inerme*, Lund.; *E. pinnatum*, Ralfs; *E. pulchellum*, Bréb.; *E. sublobatum*, Bréb.; *E. ventricosum*, Lund.

Cosmarium connatum, Bréb.; *C. Debaryi*, Arch.; *C. decedens*, Reinsch; *C. elegantissimum*, Lund.; *C. annulatum* (Näg.), Arch., var. *elegans*, Nordst.; *C. Hammeri*, Reinsch; *C. isthmium*, West; *C. Nymannianum*, Grun.; *C. ovale*, Ralfs; *C. parvulum*, Bréb.; *C. pseudamœnum*, Wille; *C. pseudopyramidatum*, Lund.; *C. pseudoconnatum*, Nordst.; *C. sphæroideum*, West; *C. subundulatum*, Wille; *C. variolatum*, Lund.

Staurastrum aculeatum, Ehrenb.; *St. anatinum*, Cooke and Wills; *St. Arnellii*, Boldt; *St. furcatum*, Ehrenb.; *St. inconspicuum*, Nordst.; *St. arachne*, Ralfs; *St. lanceolatum*, Arch.; *St. oxyacanthum*, Arch.; *St. pungens*, Bréb.; *St. scabrum*, Bréb.; *St. aristiferum*, Ralfs; *St. pileolatum*, Bréb.; *St. pterosporum*, Lund.; *St. subscabrum*, Nordst.

Having discussed the most important facts concerning the general distribution of Desmids in the British Islands, we can now return to the abundance of the Desmids in the British freshwater phytoplankton.

We have shown which areas of these Islands possess the rich Desmid-floras, and when one considers that the British lakes are almost all situated in these western areas, it is not very surprising that they possess a plankton containing numerous Desmids. Neither is it surprising that many of these should be the western types, provided that these western types are capable of withstanding the conditions of a limnetic life.

THEREFORE WE CONSIDER THAT THE DESMIDS OF THE BRITISH FRESHWATER PHYTOPLANKTON ARE DUE LARGELY, AND THE WESTERN TYPES ENTIRELY, TO THE SITUATION OF THE LAKES IN THE RICH DESMID-AREAS OF THE OLD FORMATIONS.

The antiquity of the geological formations is not a special factor in the occurrence of the numerous *plankton Desmids*, but in the occurrence of *Desmids as a whole.* The presence of numerous Desmids in the plankton of the lakes follows as a matter of course.

One does not expect an abundance of Desmids in the plankton of the large Swiss lakes. They are situated in poor Desmid-areas, and in North Switzerland the geological formations are for the most part too recent.

Most of the Central European lakes are situated in areas relatively poor in Desmidiaceæ. In Denmark the formations are Cretaceous and Jurassic, largely overlain by drift, and similarly the lakes of Northern Germany are situated on immense areas of drift, overlying comparatively recent formations. Hence the dearth of Desmids in the lakes. On the other hand, the Scandinavian lakes are situated on the old formations, and contain an abundance of Desmids, many of which are identical with those of the British lake-areas.

The Desmids of the plankton have without doubt originated from the Desmid-community of the surrounding area, although in most cases there is little resemblance between the plankton-community and that which can be observed in the surrounding drainage-basin. There is an almost complete absence from the surrounding peat-bogs and dripping rocks of those species which are most conspicuous and abundant in the plankton. The common Desmids of the bogs are only found in the limnetic region of the lakes as casual or adventitious constituents, and therefore the great majority of the Desmids brought by the rains into this limnetic region, with its new conditions of life, find it impossible to maintain their further existence, and rapidly perish. The plankton-community as a whole, as shown by Wesenberg-Lund, is a very ancient one, and this is further confirmed in the case of the British lakes by the existence of this distinct community of plankton-Desmids. We have already stated* that many of the plankton-Desmids "have existed under these pelagic conditions for a long time, as there is every indication of this in the modifications some of them have undergone, and in the species and varieties which are at present only known to occur in the plankton."

During the vast period in which Desmids have been washed by the rains from their bog habitats into the lakes, a specific selection has taken place, certain species having adapted themselves, with or without slight morphological changes, to a limnetic existence. Only those have survived which were able to withstand the new conditions.

One of the principal conditions necessary for existence in the new life would be the ability to float in the surface waters. In some species, more especially in the discoid species of *Micrasterias,* this necessity has brought about no morphological alteration; and in others, amongst which are certain species of *Cosmarium* and *Staurastrum,* there is again no change of external form, but a copious development of surrounding mucilage. In many others morphological changes have occurred, mostly in the further development of those characters which have proved of most avail in the struggle against sinking. It is thus that spines and processes have been greatly increased in length, so that many of the plankton-forms are the longest-spined forms known.† Certain species of *Staurastrum* and *Arthrodesmus* best exhibit this great development of spines. The species of *Closterium* found in the British lake-plankton are mostly adventitious constituents, and are never abundant.

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* W. and G. S. West, in 'Roy. Soc. Edin. Trans.,' vol. 41, 1905, p. 512.

† In the ordinary habitats of Desmids, and in the former habitats of plankton-species spines are commonly found well developed. This armature has probably two functions,

Nearly all the plankton-Desmids are summer and autumn constituents, and the majority of them attain their maximum abundance in September and October, during the slight fall after the maximum summer temperature.

Neither plankton-Desmids nor those which occur in other situations undergo any seasonal form-variations. This we have conclusively proved by the examination of large numbers of periodic collections of these plants. This is merely what one would expect, as environmental form-changes in Desmids occupy long periods of time. As regards the plankton, the variations in the conditions of buoyancy during the year in the surface waters of a lake are not so great as the environmental differences between the habitats in which the same species of Desmid will thrive.

Large numbers of both the plankton and bog species survive the winter in the vegetative condition, and the formation of zygospores appears to be very rare.

In Diatoms it is known that the seasonal form-variation, when it occurs, is in the colony and not in the individual, but colonial Desmids are much fewer and much less abundant than colonial Diatoms.

Lastly, we would comment upon the *cosmopolitanism of the freshwater plankton-community.* This is generally true except for the Desmids. Wesenberg-Lund* states that the numerous plankton researches in the Central European lakes have been unable to demonstrate any special, geographically localised plankton-communities. He remarks† that the "freshwater plankton-communities, in contrast to all other communities on land or water, everywhere contain the same types, nearly everywhere the same species." As regards the Desmid-flora, however, these statements do not hold good. *Wherever there are lakes with a rich Desmid-flora in the plankton, there one also gets a more or less definitely localised plankton-community.* It has been stated‡ that the Desmidiaceæ show more decided geographical peculiarities than any other group of Freshwater Algæ, notwithstanding the fact that a large number of them are cosmopolitan and ubiquitous all the world over. These geographical peculiarities occur

one of anchoring the individual to its environment, and the other to serve as a protection against Desmid-eating animals. Whether the more elongated spines of the plankton-species likewise serve a similar function of protection against the depredations of the plankton Rotifers and Entomostraca is a point which requires further investigation.

* Wesenberg-Lund, *loc. cit.*, 1908, p. 293.

† *Loc. cit.*, p. 313.

‡ G. S. West, in 'Linn. Soc. Bot. Journ.,' vol. 38, 1907, p. 82; W. and G. S. West, in 'Ann. Roy. Bot. Gard., Calcutta,' vol. 6, part 2, 1908, p. 176.

in the Desmid-community of the plankton quite as much as in the general Desmid-community of the surrounding country. In fact, they appear to be well marked.*

Even with the meagreness of our present knowledge we can recognise three distinct plankton-communities of Desmids, which can at once be distinguished from each other, and which form a most interesting comparison. These are (1) the Desmids of the British (and to a certain extent of the Scandinavian) plankton, (2) the Desmids of the plankton of Victoria Nyanza, and (3) the Desmids of the Victorian plankton (as exemplified by the Yan Yean Reservoir). There are doubtless several other distinct plankton-communities of Desmids, notably in the South American and the Indo-Malayan regions. There are marked geographical peculiarities in the general Desmid-community of these regions, and should any of the lakes be found on investigation to possess a Desmid-plankton, it is highly probable that many of the species will possess their proper geographical character.

* In considering this question it should be borne in mind that Desmids in the vegetative condition cannot be blown about by the wind, as even partial desiccation is almost invariably fatal. Also, that in most species zygospores are very rarely formed, and that no zygospore has yet been observed of any of the typical plankton-species. The only Desmids which appear to survive a partial desiccation are certain species of *Cylindrocystis* and *Penium*, and possibly of *Mesotænium*.

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Freshwater Rhizopods. With the kind regards of the author.

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[*Extracted from the* Linnean Society's Journal—Zoology,
vol. xxix.]

Observations on Freshwater Rhizopods, with some Remarks on their Classification. By G. S. West, M.A., F.L.S., Professor of Natural History at the Royal Agricultural College, Cirencester.

(Plate 13.)

Since my first communication to the Linnean Society on the subject of freshwater Rhizopods, in 1901, I have had the opportunity of examining a considerable amount of material from some of the outlying districts of the British Isles, and several animals of this class have come under my notice concerning which I can find no previous mention. Two of these are undescribed species of the genus *Hyalosphenia*, one is a species of *Sphenoderia* with a prettily constructed shell, and another is a strange nude form referable to Cienkowski's genus *Nuclearia*.

Rhizopods are almost cosmopolitan in their distribution, and few animals exhibit a wider range of variation. In many cases it is almost impossible to define clearly their specific differences, and little attention has been given in the past to the study of the variation of the more abundant forms.

Altitude appears to have little effect on most species of Rhizopods, as they occur in abundance in suitable localities up to several thousands of feet above the sea-level. Leidy * has collected them at 10,000 ft. in the Uinta Mountains; and I have observed *Trinema enchelys* in collections from the Chilian Andes at 11,000 ft. There is apparently no restriction of special forms to alpine or subalpine situations †, although a few species, such as *Assulina seminulum* and *Heleopera petricola*, are most frequent in elevated districts, and a few others seem to have a preference for low-lying ponds and ditches.

In examining a large number of collections from the West of Scotland, it was noticed that Rhizopods were relatively less abundant in the Outer Hebrides than on the mainland of Sutherland and Inverness. As the collections numbered more than 500, and were fairly representative, this feature, although possibly quite accidental, is deserving of notice. The following species were observed from the Outer Hebrides :—

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* Leidy, Freshw. Rhiz. N. Amer. 1879, p. 13.

† This is also fairly evident from the lists of alpine and subalpine Rhizopods recorded from Sweden and Finland by Lagerheim. *Cf.* Geol. Fören. Förhandl. 1902, Bd. xxiii. Häft. 6, no. 209, pp. 471–472.

From Lewis :—*Nuclearia conspicua*, *Amœba proteus*, *Cochliopodium bilimbosum*, *Arcella vulgaris* and var. *gibbosa*, *Centropyxis aculeata*, *Difflugia constricta*, *D. pyriformis*, *D. acuminata*, *D. Solowetzkii*, *D. corona*, *D. globulosa*, *Nebela collaris*, *N. flabellulum*, *N. carinata*, *Heleopera petricola*, *Quadrula symmetrica*, *Euglypha alveolata*, *E. ciliata*, *Sphenoderia lenta*, *Assulina seminulum*, *Trinema enchelys*, *Cyphoderia ampullacea*.

From Harris :—*Vampyrella lateritia*, *Pelomyxa palustris*, *Amœba verrucosa*, *Dactylosphærium radiosum*, *Cochliopodium bilimbosum*, *Arcella vulgaris*, *A. discoides*, *Centropyxis aculeata*, *Difflugia pyriformis*, *D. globulosa*, *Nebela flabellulum*, *Quadrula symmetrica*, *Hyalosphenia platystoma*, *Euglypha alveolata*, *E. ciliata*, *E. cristata*, *Trinema enchelys*, *Pamphagus hyalinus*.

From North Uist:—*Dactylosphærium radiosum*, *Arcella vulgaris*, *Centropyxis aculeata*, *Difflugia pyriformis*, *D. acuminata*, *E. globulosa*, *Nebela collaris*, *Trinema enchelys*, *Euglypha ciliata*, *Quadrula symmetrica*.

From South Uist:—*Amœba verrucosa*, *Dactylosphærium radiosum*, *Arcella vulgaris* and var. *gibbosa*, *Centropyxis aculeata*, *Difflugia constricta*, *D. pyriformis*, *D. acuminata*, *Nebela collaris*, *Euglypha ciliata*, *Sphenoderia lenta*, *Trinema enchelys*.

From Benbecula :—*Amœba proteus*, *Arcella vulgaris*, *Difflugia globulosa*, *D. pyriformis*, *Euglypha alveolata*, *E. ciliata*, *Trinema enchelys*.

The two following species were collected on St. Mary's, Scilly Islands, and add to the distribution of British Rhizopods :—*Amœba verrucosa* and *Difflugia globulosa*.

The systematic position of *Vampyrella* and allied genera has long been a matter of considerable doubt. It seems clear that the two genera *Vampyrella* and *Nuclearia* are very closely allied, on account of their structure and the nature of their pseudopodia, even though the latter genus does not possess the curious red pigment found in the protoplasm of *Vampyrella*. It seems equally clear that they can hardly be retained in Lankester's 'Proteomyxa,' a group instituted to include a number of genera concerning which more information was required. The long pseudopodia of *Vampyrella* are straight, often radiating, and always considerably attenuated towards a fine apex; they are frequently branched, and the branching takes place almost

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invariably near their broad bases. The same is true of Cienkowski's *Nuclearia*; but in several other genera which were included in the 'Proteomyxa,' such as *Protomyxa*, Haeckel, and *Biomyxa*, Leidy, the pseudopodia are anastomosing and often very irregular; they are bent and of variable width, exhibiting none of the rigidity shown by the straighter pseudopodia of *Vampyrella* or *Nuclearia*. The entire animals can be likened unto a *Gromia* without its shell, whereas such is not the case in *Vampyrella* or *Nuclearia*.

The nuclei of the different forms of Rhizopods are very similar and exhibit little variation in structure. The characters of the nucleus are to my mind of much less importance in these animals than might at first be imagined, and are of little classificatory value. It is difficult to see how such a uniformity of character as is exhibited by the nuclei of Rhizopods could be utilized as a basis of classification. The nucleus may also be absent in some species of a genus, although present in others (cf. *Cochliopodium minutum*).

Considering the foregoing facts, it appears advisable to remove the two genera *Vampyrella* and *Nuclearia* from the 'Proteomyxa,' chiefly on account of the nature of their pseudopodia, and place them in a separate order of the class Rhizopoda—the order 'Vampyrellida'*. By the establishment of this order the fresh-water Rhizopods fall under four orders, which are characterized as follows:—

Order 1. **Proteomyxa.** Nude Rhizopods which in the amœboid condition possess an irregular mass of body-protoplasm, often reticulate, and anastoming pseudopodia of considerable irregularity.

e. g. *Biomyxa*, Leidy; *Gymnophrys*, Cienk.

Order 2. **Vampyrellida.** Nude Rhizopods which in the amœboid condition possess a body-protoplasm of more or less definite form, frequently globular or often elongated; with straight attenuated pseudopodia, often branched at the base.

e. g. *Vampyrella*, Cienk. (incl. *Leptophrys*, Hertwig and Lesser); *Nuclearia*, Cienk. (incl. *Heliophrys*, Greeff).

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* *Cf.* G. S. West, "Some British Freshw. Rhiz. and Heliozoa," Journ. Linn. Soc., Zool. xxviii. 1901, pp. 308 & 333.

Order 3. **Amoebaea.** Nude Rhizopods which in the amœboid condition possess a very irregular mass of body-protoplasm; pseudopodia lobose, varying in form from mere undulations of the surface to elongate blunt processes (rarely attenuated and acute), sometimes branched, but never reticulate.
e. g. *Amœba*, Ehrenb., *Pelomyxa*, Greeff, *Dactylosphærium*, Hertwig & Lesser.

Order 4. **Testacea.** Rhizopods in which the body-protoplasm is enclosed in a shell of variable construction; pseudopodia blunt and lobose or thread-like and attenuated to fine points, often branched and rarely reticulate.
e. g. *Difflugia*, Leclerc, *Arcella*, Ehrenb., *Euglypha*, Dujardin, *Pamphagus*, Bailey, *Diplophrys*, Barker, &c., &c.

The following is a systematic account of some of the most interesting Rhizopods I have recently examined.

Class RHIZOPODA.

Order **Vampyrellida.**

Genus Nuclearia, *Cienkowski.*

1. Nuclearia conspicua, sp. n. (Pl. **13.** figs. 16–19.)

Protoplasmic body subglobose or angularly rounded; protoplasm undifferentiated, granulose, containing numerous large vacuoles, with a single large spherical nucleus which exhibits a punctate appearance; pseudopodia fairly numerous, stout, rigid, generally with one or two branches which are a little divergent and attenuated to fine points.

Diameter of body 83–120 μ; length of pseudopodia 17–54 μ.

Hab. In boggy pools, Lewis, Outer Hebrides.

This Rhizopod occurred in considerable profusion amongst numerous Desmids and other Algæ in small pools. The animals are of much larger size than *N. delicatula*, Cienk., or *N. simplex*, Cienk., and the protoplasm is much more vacuolated. There is a single nucleus present in each individual, but no contractile vacuoles were observed. The pseudopodia are protruded irregularly from the surface of the body-protoplasm, often in small clusters. They are broad at the base, generally straight and

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much attenuated, and almost always branched. Except for their perfectly smooth exterior and absence of granules, they are very like those present in the genus *Vampyrella.*

This species is a voracious feeder, and many of the individuals were gorged with Desmids. The protoplasm contained no green colouring-matter, the chlorophyll of the Desmids disappearing very soon after ingestion. The pseudopodia were frequently entirely retracted, the animals then remaining in a quiescent state for a long time (fig. 18). In this state they much resembled the quiescent stages of *Vampyrella pedata*, Klein, but could be distinguished by the numerous vacuoles and the absence of the red pigment.

Slight stimulation of the animals, either mechanical or with reagents, caused a contraction of the pseudopodia, so that they became undulated, as shown in fig. 19.

I have previously pointed out that *Heterophrys varians*, Schulze, is identical with *Heliophrys variabilis*, Greeff, and that the animals in question do not belong to Archer's genus *Heterophrys.* I am now quite convinced that both are forms of Cienkowski's *Nuclearia delicatula*, and are Rhizopods which should be placed in the order Vampyrellida.

Genus VAMPYRELLA, *Cienkowski.*

2. VAMPYRELLA LATERITIA, *Leidy*, *Freshw. Rhiz. N. Amer.* 1879, p. 253, pl. 45. figs. 10–16.—Amœba lateritia, *Fresenius*, 1856–8.—Vampyrella Spirogyræ, *Cienk. in Archiv für mikr. Anat.* i. 1865, p. 218, pls. 12–13. figs. 44–56.

Hab. West of Tarbert, Harris, Outer Hebrides.

Numerous examples were observed amongst various algæ, but all of them were sluggish, and none were observed feeding.

Order **Amœbœa.**

Family LOBOSA.

Genus PELOMYXA, *Greeff.*

3. PELOMYXA PALUSTRIS, *Greeff, in Archiv für mikr. Anat.* x. 1870, pp. 51–72, pls. 3–4.

Hab. Near Tarbert, Harris, Outer Hebrides.

Not uncommon in boggy pools amongst submerged *Sphagnum.*

Genus Dactylosphærium, *Hertwig & Lesser*.

4. Dactylosphærium radiosum, *Blochmann*, *Die mikr. Thierwelt des Süsswass.*, I. *Protozoa* (Hamburg, 1895), p. 14.—Amœba radiosa, *Ehrenb.*

Hab. Gortahork, Co. Donegal, Ireland.

From the above locality a number of curious forms of this Rhizopod were observed in which the pseudopodia were distinctly twisted (fig. 2). This was not merely the condition of one or two pseudopodia of a single individual, but was general among the majority of the specimens. The condition was not brought about by any specially applied stimulation, and, although the pseudopodia exhibited slow movements, they made no attempt to unwind themselves. The same state was noticed and figured by Penard (in Mém. Soc. Phys. et d'Hist. Nat. Genève, tom. xxxi. no. 2, 1890, pl. 2. fig. 75) from Wiesbaden.

Diameter of body 16–19 μ; length of pseudopodia 23–46 μ.

Order **Testacea.**

Family Arcellina.

Genus Difflugia, *Leclerc*.

5. Difflugia acuminata, *Ehrenb. Infus.* 1838, p. 131, pl. 9. fig. 3; *Leidy*, *Freshw. Rhiz. N. Amer.* 1879, p. 109, pl. 13.

Var. amphora, *G. S. West*, *in Journ. Linn. Soc.*, *Zool.* xxviii. (1901), p. 319.—D. amphora, *Penard*, *in Mém. Soc. Phys. et d'Hist. Nat. Genève*, tom. xxxi. no. 2, 1890, p. 139, pl. 13. figs. 55–65.

Some strange forms of this variety were observed from Y Foel Fras, N. Wales, in which large numbers of the empty cells of *Chlorobotrys regularis*, Bohlin, were incorporated with the shell. They were certainly the most extraordinary Rhizopod-shells I have ever examined. The cells of the alga are globular and the cell-walls are siliceous, and the entire shell of the *Difflugia* appeared to be built up of an accumulation of the empty cells of the unicellular alga. Length of shells 260–290 μ.

6. Difflugia Solowetzkii, *Mereschk.*; *Levander*, '*Material zur Kenntniss der Wasserfauna in der Umgebung von Helsingfors.*' *Acta Soc. pr. Fauna et Flora Fennicæ*, xii. no. 2, 1894, p. 18,

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pl. 1. fig. 13.—D. elegans, *Penard, l. c.* p. 140, pl. 4. figs. 4–11.—D. acuminata, *Ehrenb.*, var. elegans, *G. S. West, in Journ. Linn. Soc., Zool.* xxviii. (1901) p. 319, pl. 28. figs. 11–12.

Hab. Rhiconich, Sutherland.

It seems probable that this *Difflugia* retains its characters sufficiently well to be regarded in the light of a species. The attenuated apex is always bent at a considerable angle from the longitudinal axis and is invariably perforated. The size of the shell is also much less than the average size of *D. acuminata*, Ehrenb.

Genus NEBELA, *Leidy*.

7. NEBELA DENTISTOMA, *Penard, l. c.* p. 162, pl. 6. figs. 98–100; pl. 7. figs. 1–5.—*G. S. West, in Journ. Linn. Soc., Zool.* xxviii. (1901) p. 322.—N. crenulata, *Cash.*

Hab. Lund's Fell, N. Yorkshire; amongst mosses.

Genus HYALOSPHENIA, *Stein*.

8. HYALOSPHENIA PLATYSTOMA, sp. n. (Pl. **13**. figs. 3–6.)

Rather small; shell ovoid in front view, with a semicircular apex and a widely truncate base, consisting of a colourless, transparent, chitinoid membrane; sides of shell slightly convex and mouth very wide; in side view, shell narrowly ovoid, with no trace of a constriction towards the apex, slightly notched at the mouth. Protoplasmic body held in position by several fine strands passing to the inner surface of the shell, inferior part clear, superior part granular and filled with food-particles; pseudopodia two, short and lobose; nucleus dorsal and prominent; contractile vacuoles not observed.

Length of shell 40–42 μ; breadth of shell 28–32 μ; breadth of mouth 21–26 μ; thickness of shell 14–15 μ.

Hab. Near Tarbert, Harris, Outer Hebrides.

Numerous active specimens of the above species were observed in a collection from a *Sphagnum*-bog. The small size of the shell and the extremely broad mouth are features which easily distinguish it. In the side view, there is no trace of a constriction towards the apex of the shell, and there is a distinct line of demarcation between the lower part of the body-protoplasm, which gives origin to the pseudopodia, and the upper granular portion.

The species stands nearest to *H. minuta*, Cash (Trans. Manchester Micr. Soc. 1891, p. 49, pl. 11. figs. 3–4). but the form of the shell is different, the mouth being much broader and more truncate, and the body-protoplasm and pseudopodia exhibit rather different characters.

9. HYALOSPHENIA INCONSPICUA, sp. n. (Pl. **13**. figs. 7–11.)

Very minute; shell thin, of a reddish-brown colour, in front view with an almost circular outline, the basal portion being slightly protracted to form a short neck; mouth small and truncate; in side view, shell ovate-elliptical in form, with a notched mouth. Protoplasmic body occupying only about half the cavity of the shell and furnished with a small nucleus; with one short pseudopodium; contractile vacuoles not observed.

Length of shell 14·5–17 μ; breadth of shell 12·5–16 μ; breadth of mouth 6·5–7·7 μ; thickness of shell 8·6 μ.

Hab. Lough Gartan, Co. Donegal, Ireland.

This minute *Hyalosphenia*, which is considerably smaller than any other known species, was observed in quantity from the above locality in May 1901. The almost circular outline of the shell and the reddish-brown colour are characteristic. The animals were very sluggish, and only protruded one small pseudopodium.

Family EUGLYPHINA.

Genus EUGLYPHA, *Dujardin.*

10. EUGLYPHA CRISTATA, *Leidy, in Proc. Acad. Nat. Sci.* Philad. 1874, p. 226; *Freshw. Rhiz. N. Amer.* 1879, p. 218, pl. 37. figs. 1–4.

Length of shell (without bristles) 65–104 μ; breadth 27–31 μ.

Hab. Rhiconich, Sutherland; frequent. Also near Tarbert, Harris, Outer Hebrides.

Some of the examples were very rounded at the apex, but others were more attenuated towards the apex, and also furnished with a slight neck at the base.

Genus SPHENODERIA, *Schlumberger.*

11. SPHENODERIA PULCHELLA, sp. n. (Pl. **13**. figs. 12–15.)

Shell ovoid or ellipsoid, in vertical view circular, composed of

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six longitudinal rows of widely hexagonal plates, 8 or 9 plates in each row, with a short cylindrical neck at one pole; mouth circular, often with an irregular border; plates transparent, chitinoid, colourless or pale yellow; body-protoplasm protruding some three or four delicate thread-like pseudopodia.

Length of shell 33–42 μ; diameter of shell 21–25 μ; diameter of mouth 5–7·8 μ.

Hab. Glenties and near Lough Machugh, Co. Donegal; and east of Recess, Co. Galway, Ireland.

Living specimens of this pretty little Rhizopod were only observed from Glenties, Co. Donegal. From the other localities only empty shells were seen, but these are unmistakable.

It is nearest to *S. macrolepis*, Leidy, but is easily distinguished by its larger size, smaller mouth, and by the six equal rows of plates. In most cases the short neck was cylindrical, but a few specimens were seen in which it was slightly compressed. The form of the shell and the arrangement of the plates at once distinguish it from *S. lenta*, Schlumbg.

Family GROMIINA.

Genus PAMPHAGUS, *Bailey*.

12. PAMPHAGUS HYALINUS, *Leidy*, *Freshw. Rhiz. N. Amer.* 1879, p. 194, pl. 33. figs. 13–17.—Arcella? hyalina, *Ehrenb.*, 1838. —Gromia hyalina, *Schlumberger*, 1845.—Lecythium hyalinum, *Hertwig & Lesser*, 1874.

Hab. Sligachan, Skye; abundant in pools.

The animals were all somewhat elongate, about 40–50 μ in length and 26–29 μ in breadth, and the pseudopodia were extended more than is usual for this species, reaching a length of 73 μ.

Family AMPHISTOMINA.

Genus DIPLOPHRYS, *Barker*.

13. DIPLOPHRYS ARCHERII, *Barker*, *in Qu. Journ. Micr. Sci.* 1868, p. 123; *Hertwig & Lesser*, *in Archiv für mikr. Anat.* x. (1874). Suppl. p. 139, pl. 3. fig. 9.

Hab. Loch Gatny, Co. Donegal.

EXPLANATION OF PLATE 13.

cv=contractile vacuole. *n*=nucleus. *ps*=pseudopodia. *v*=vacuole.
All the figures × 520.

Figs. 1–2. *Dactylosphærium radiosum*, Blochmann. Two forms; fig. 2, showing spirally-twisted pseudopodia.

3–6. *Hyalosphenia platystoma*, sp. n. Figs. 3–5 showing the front view of the shell with its broad aperture; fig. 6, seen from the side. Fig. 4 shows a curiously contracted state of the animal in which the body-protoplasm is closely applied to the dorsal part of the shell.

7–11. *Hyalosphenia inconspicua*, sp. n. Fig. 7, living animal, showing pseudopodium and nucleus; figs. 8–11, empty shells. Fig. 11 is the basal view of a shell showing the elliptical mouth.

12–15. *Sphenoderia pulchella*, sp. n. Figs. 12, 14, and 15, empty shells; fig. 13, living animal. Fig. 15 is the basal view of the shell, showing the small, round aperture.

16–19. *Nuclearia conspicua*, sp. n. Figs. 16 and 17, animals with pseudopodia extended; fig. 18, contracted state of the animal. These animals contain a number of Desmids, the bodies of which have been more or less digested. Fig. 19, two pseudopodia after slight mechanical stimulation.

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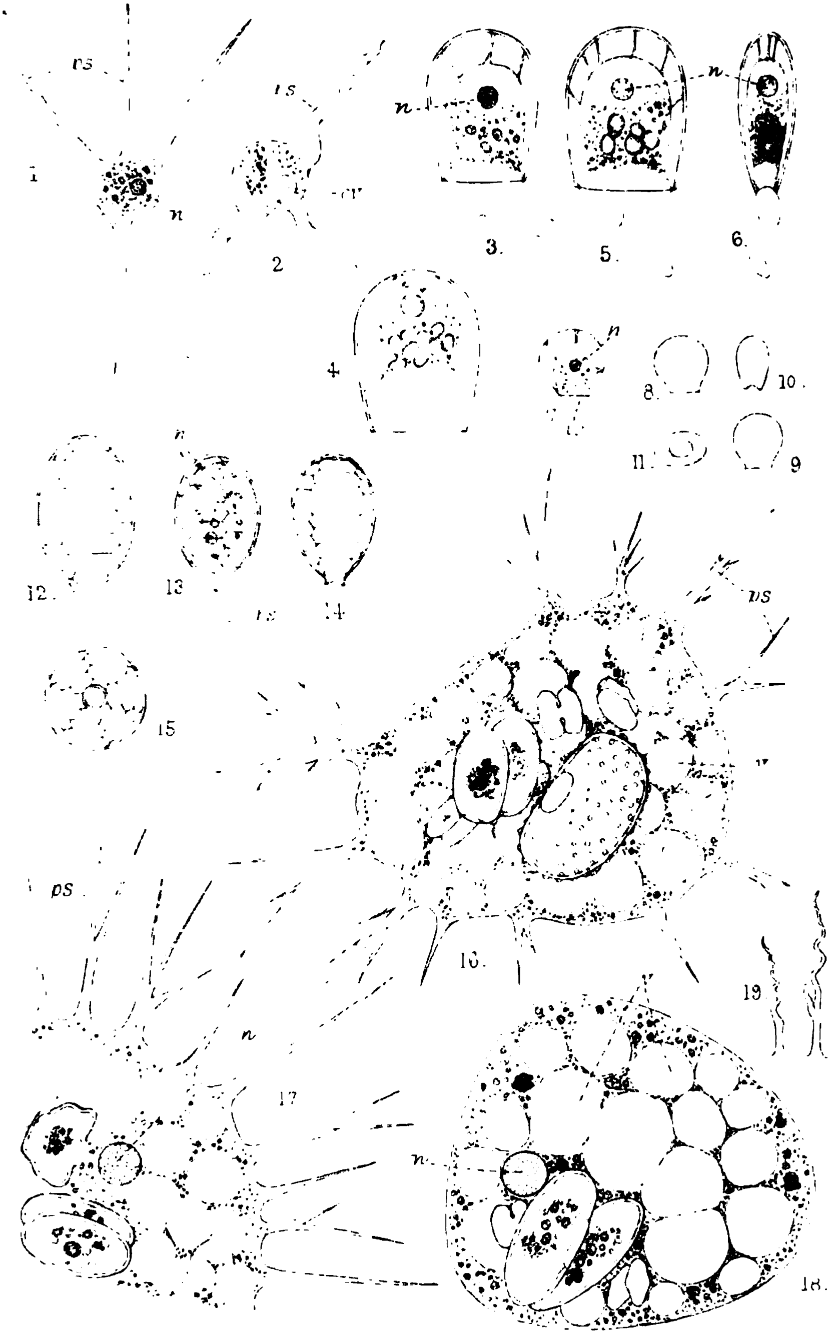

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BRITISH RHIZOPODS.

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British Freshwater
Rhizopods and Heliozoa.

With the kind regards of the author.

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[*Extracted from the* LINNEAN SOCIETY'S JOURNAL—ZOOLOGY,
vol. xxviii.]

ON SOME

BRITISH FRESHWATER RHIZOPODS AND HELIOZOA.

BY

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NATURAL HISTORY AT THE ROYAL AGRICULTURAL COLLEGE, CIRENCESTER.

On some British Freshwater Rhizopods and Heliozoa. By G. S. West, B.A., F.L.S. A.R.C.S., Hutchinson Student of St. John's College, Cambridge; Professor of Natural History at the Royal Agricultural College, Cirencester.

(PLATES 28-30.)

DURING the past few years I have been collecting and examining from every possible situation numerous small plants belonging to the Algæ, and amongst them I have found Rhizopods and Heliozoa in abundance. Most of the interesting forms of these groups I carefully sketched, in some instances making detailed and extended examinations of them, and I now possess an accumulation of notes and drawings, many of which may be deserving of notice.

Some of the observations in this paper relate to the habits and structure of certain of the Rhizopods and Heliozoa; others are descriptive of peculiar forms of the commoner and more abundant species; and others again are records of rarer and less-known species. I also give descriptions and figures of six animals which I believe have not previously been observed, one of which I have referred to a new genus (p. 325).

A point of considerable interest is the presence of a perforation at the apex of the shell of some forms of *Difflugia acuminata*, Ehrenb. The shell thus possesses two openings, one at each end, as in the case of those Rhizopods referred to the family *Amphistomina*.

As the remarkable animals belonging to the genus *Vampyrella* possess characters by which they are sharply demarcated from the other Rhizopods, I have placed them in a separate order—the *Vampyrellida*.

I have paid little attention to the species of *Amœba*, and it is very probable that I have overlooked several that are abundant and widely distributed.

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Class RHIZOPODA.

Order **AMŒBŒA.**

Fam. LOBOSA.

Gen. AMŒBA, *Ehrenb.*

1. AMŒBA PROTEUS, *Leidy, in Proc. Acad. Nat. Sci. Philad.* 1878, p. 99; *Freshw. Rhiz. N. Amer.* 1879, p. 31, t. i. ff. 1–8, t. ii. ff. 1–13.—Volvox proteus, *Pallas*, 1766. Amœba princeps, *Ehrenb. Abhandl. Akad. Wiss. Berlin*, 1831, pp. 28, 79; *Infus.* 1838, p. 126, t. viii. f. x.

Generally distributed; small forms most abundant. Some very large specimens were obtained from amongst *Utricularia minor* at Cocket Moss, near Giggleswick, W. Yorkshire. They possessed a very large elliptical nucleus, and were mostly gorged with Diatoms and Desmids.

2. AMŒBA VILLOSA, *Wallich, in Ann. Mag. Nat. Hist.* 1863, xi. p. 287, t. viii.; p. 366, t. ix.; p. 434, t. x. ff. 5–9.—A. princeps, *Carter, in Ann. Mag. Nat. Hist.* 1863, xii. pp. 30, 44, t. iii. ff. 1–3. Trichamœba hirta, *Fromontel.*

In a back-water of the R. Aire at "Seven Arches," near Bingley, W. Yorkshire, this species was in enormous abundance. The muddy bottom of the shallow water was covered with a thick black slime consisting entirely of *A. villosa.*

3. AMŒBA VERRUCOSA, *Ehrenb. Infus.* 1838, p. 126, t. viii. f. xi; *Carter, in Ann. Mag. Nat. Hist.* 1857, xx. p. 37, t. i. ff. 12, 13.—A. natans, *Perty*, 1852. A. quadrilineata, *Carter*, 1856. Thecamœba quadripartita, *Fromontel.*

A very abundant and widely distributed species. I obtained it in quantity amongst mosses at over 3000 ft. elevation on Snowdon, N. Wales.

Gen. PELOMYXA, *Greeff.*

4. PELOMYXA PALUSTRIS, *Greeff, in Archiv für mikr. Anat.* 1870, x. pp. 51–72, t. iii.–v.

Length of animals approximately 500 μ.

Amongst *Sphagnum* in very stagnant water in a bog above the lakes at Capel Curig, N. Wales.

5. Pelomyxa villosa, *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 73, t. v., t. viii. ff. 31–33.—Amœba sabulosa, *Leidy*, 1874.

Terrington, N. Yorkshire, in ditches. Devil's Jumps, Frensham, Surrey, in bog-pools. Ashurst Bog, New Forest, Hants.

This is a smaller animal than *P. palustris*, Greeff, and possesses a terminal villous patch similar to that of *Amœba villosa.*

Gen. Dactylosphærium, *Hertwig & Lesser.*

6. Dactylosphærium radiosum, *Blochmann, Die mikr. Thierwelt des Süsswass.*, I. *Protozoa, Hamburg*, 1895, p. 14.—Amœba radiosa, *Ehrenb. Abh. Akad. Wiss. Berlin*, 1830, p. 80; *Infus.* 1838, p. 128, t. viii. f. xiii; *Carter, in Ann. Mag. Nat. Hist.* 1856, p. 243, t. v. ff. 10–18; *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 58, t. iv. ff. 1–18. A. brachiata, *Dujardin*, 1841. A. ramosa, *Duj.*, 1841.

General in pools on heaths, and in bogs and pools in hilly districts.

A peculiar form was very abundant in the pools on Esher West-end Common, Surrey, in Feb. 1894. It had a spherical body of 12–19 μ in diameter, and five (sometimes six) long, attenuated pseudopodia. Length of pseudopodia 25–54 μ. I could find no trace of this form in the same locality in either of the two following years. (Pl. 28. fig. 5.)

The usual mountain form of the animal possesses a subspherical or ellipsoidal body, 32–50 μ in diameter, and from twelve to twenty long and exceedingly narrow pseudopodia. Length of pseudopodia 25–70 μ.

An extraordinary form was met with from Llyn Idwal, N. Wales. The body was more or less polygonal, 27–34 μ in diameter, and the pseudopodia were six in number, very slender, and of extraordinary length (52–107 μ). (Pl. 28. fig. 4.)

7. Dactylosphærium vitreum, *Hertwig & Lesser, in Archiv für mikr. Anat.* 1874, x. Suppl. p. 54, t. ii. f. 1.

Shelf, West Yorkshire. Diameter of body 48–54 μ; length of pseudopodia 29–48 μ.

All the animals possessed numerous radiating pseudopodia, seemingly entirely composed of the ectoplasm, the endoplasm extending a short way into their expanded bases. The ectoplasm

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was homogeneous and very refractive. The endoplasm was dark-coloured and crowded with small granules; it also contained a well-marked nucleus and one contractile vacuole.

The genus *Dactylosphærium* appears to be sufficiently well marked off from *Amœba.* The actual body of the animal is not strictly amœbiform, but always more or less spherical, sending out numbers of long, comparatively thin, attenuated pseudopodia. From what I have seen of these animals, I consider that *Dactylosphæria* exhibit less active movements than *Amœbæ.* Some of the mountain forms of *D. radiosum* keep the same pseudopodia protruded to a variable extent for hours at a time.

Fam. RETICULOSA.

Gen. GYMNOPHRYS, *Cienk.*

8. GYMNOPHRYS COMETA, *Cienkowski, in Archiv für mikr. Anat.* 1876, xii. p. 31, f. 25; *Blochmann, Die mikroskop. Thierwelt des Süsswass.*, I. *Protozoa*, *Hamburg*, 1895, p. 14, t. i. f. 9.

Near Brigg, Lincolnshire. (Pl. 28. fig. 3.) From this locality several specimens of an animal were obtained which may, perhaps, be Cienkowski's *Gymnophrys cometa.* The body was somewhat small, being about 25 μ in length and 18 μ in breadth, and some of them were distinctly constricted in the middle as if undergoing division. The pseudopodia varied in number from three to five at either end of the body, and sometimes reached a length of 100 μ. They were delicate and hyaline, frequently much branched, and occasionally anastomosed with one another. The branches arose suddenly at a considerable angle from the main pseudopodial filament and exhibited a very rigid appearance. Small granules moved slowly along the pseudopodia, generally in groups.

Contractile vacuoles were entirely absent; this character and the peculiar nature of the rigidly-branched pseudopodia easily distinguishing it from *Biomyxa vagans,* Leidy, a Rhizopod with which it possesses much affinity.

No nucleus could be detected in any of the individuals.

Archer (in Qu. Jour. Micr. Sci. 1877, xvii. p. 349) states that Cienkowski's species reminds him of "a portion of the mass of a *Gromia* become isolated and detached by some readily conceivable force, having wandered too far from the headquarters." Curiously enough, the collection in which I observed what I take to be the animal described by Cienkowski contained large numbers of a *Gromia*.

Order TESTACEA.

Fam. ARCELLINA.

Gen. COCHLIOPODIUM, *Hertwig & Lesser.*

9. COCHLIOPODIUM BILIMBOSUM, *Leidy*, *Freshw. Rhiz. N. Amer.* 1879, p. 184, t. xxxii. ff. 1–25.—Amœba bilimbosa, *Auerbach*, 1856. Cochliopodium pellucidum, *Hertwig & Lesser*, *in Archiv für mikr. Anat.* 1874, x. Suppl. p. 66, t. ii. f. 7.

I find this animal to be somewhat scarce. I have only obtained really good examples of it from five localities, viz.:—near Brigg, Lincolnshire; near Lough Neagh, Ireland; near Gortahork, Co. Donegal, Ireland; Llyn Ogwen, and the lakes at Capel Curig, N. Wales.

Diameter of shell 32–44 μ.

10. COCHLIOPODIUM MINUTUM, sp. n. (Pl. 28. figs. 6–10.)

Very minute, with a cup-shaped delicate shell having an extremely wide mouth. Body-protoplasm granular; pseudopodia somewhat irregular, usually attenuated at the extremity. Nucleus absent. One or two vacuoles present in some individuals, but entirely absent in others.

Diameter of shell 12·4–13·5 μ.

Llyn-y-cwm-ffynon, N. Wales.

This small *Cochliopodium* was observed in abundance among numerous Desmids in washings of *Isoëtes*. The shell is very delicate, with a widely open mouth, and is structureless: it is also flexible, assuming various unsymmetrical shapes as it accommodates itself to the animal's movements. Seen from above the shell is usually circular, but it frequently exhibits an irregularly undulate margin.

The pseudopodia are commonly somewhat flattened extensions of colourless ectoplasm with distinctly attenuated ends. Sometimes they are flat, sheet-like expansions of irregular outline, which now and then fuse together, forming a bell-shaped ring of ectoplasm extending outwards from the edges of the mouth. In all cases they are colourless, hyaline projections showing no trace of any granulation. The animals, when active, extend

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and retract these pseudopodia with considerable rapidity of movement.

The body-protoplasm within the shell is of a much darker hue than the pseudopodia, and, with the exception of a few instances in which it was homogeneous, exhibits a number of prominent granules. No nucleus was present in any of the individuals, but some possessed one or more vacuoles, which, however, were never observed to pulsate.

C. minutum is readily distinguished from *C. bilimbosum* by its minute size, its more delicate shell, and the absence of a nucleus. Moreover, it does not possess the punctate, expanded band of the shell in the region of the mouth.

11. **Cochliopodium vestitum**, *Archer, in Qu. Jour. Micr. Sci.* 1876, p. 299; 1877, p. 334; *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 188, t. xxxii. ff. 26–28.—Amphizonella vestita, *Archer, l. c.* 1871, xi. pp. 112, 135, t. vi. ff. 1–6. Cochliopodium pilosum, *Hertwig & Lesser, in Archiv für mikr. Anat.* 1874, x. Suppl. p. 78.

Esher West-end Common, Surrey. It occurred in great abundance in ditches and ponds among various Algæ: June–Aug. 1894–5. Diameter without spines 25–45 μ; length of spines 3·7–5 μ. The majority of the individuals were colourless, but a few possessed chlorophyll granules.

Sheep's Green, Cambridge, July 1896, somewhat scarce. None of the individuals possessed any colouring-matter.

I am inclined to agree with Schulze (in Archiv für mikr. Anat. xi. p. 337) that the chlorophyll granules frequently found in individuals of this Rhizopod have been originally taken into the body-protoplasm as food.

12. **Cochliopodium longispinum**, sp. n. (Pl. 28. fig. 1.)

Shell very thin and delicate, subspherical, with a broadly open, somewhat prominent mouth; exterior of shell covered with very long, extremely delicate, hair-like, radiating spines. Body-protoplasm granular, and with many highly-refractive globules. Nucleus large and round, situated towards the fundus. With one (or sometimes more) contractile vacuoles. Pseudopodia few, broad and expansive, granular in the central part but hyaline and indistinct towards the edges.

Diameter of shell 42 μ; diameter of mouth of shell 34 μ; length of spines 23–29 μ.

Wicken Fen, Cambridgeshire July 1899, amongst *Chara hispida*.

The thin shell and the extremely long, delicate spines readily distinguish this species from *C. vestitum*, Archer. The spines are also more numerous than in the latter species, and the mouth of the shell is comparatively broader than in any specimen of *C. vestitum* I have seen. The pseudopodia are also thicker and more expansive, and the refractive globules from the body of the animal often pass into them. No green colouring-matter was obtained in any of the examples.

Gen. Arcella, *Ehrenb.*

13. Arcella vulgaris, *Ehrenb. Abhand. Akad. Wiss. Berlin*, 1830, pp. 40, 53, etc. t. i. f. vi; *Infus.* 1838, p. 133, t. ix. f. v; *Carter, in Ann. Mag. Nat. Hist.* xviii. 1856, p. 128, t. vii. f. 79; 1864, xiii. p. 30, t. ii. f. 14.—A. hemisphærica, *Perty*, 1852. Arcellina vulgaris, *Carter*, 1856.

Generally distributed throughout the British Islands.

Var. gibbosa.—*Arcella vulgaris*, Leidy, Freshw. Rhiz. N. Amer. 1879, t. xxvi. ff. 23–24.—*Arcella gibbosa*, Penard, in Mém. Soc. de Phys. et d'Hist. Nat. de Genève, 1890, tome xxxi. no. 2, p. 155, t. v. ff. 96–99, t. vi. f. 1.

The convex surface of the shell faceted, the facets being circular depressions which fade away towards the edges of the shell. Shell dark brown in colour, sometimes nearly black.

In bogs, New Forest, Hants. In pools, Llangelynin, near Conway, N. Wales. Bog about two miles south of Clapham, W. Yorkshire.

From the last-named locality the specimens were very large, exceeding in dimensions any forms of the species I have yet come across. The diameter of the shell was in some cases as much as 240 μ.

14. Arcella discoides, *Ehrenb. Monatsb. Akad. Wiss. Berlin*, 1843, p. 139; *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 173, t. xxviii. ff. 14–38.

Widely distributed, but not so abundant as *A. vulgaris*. At 2200 ft. on Glyder Fach, N. Wales.

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15. **Arcella mitrata**, *Leidy, in Proc. Acad. Nat. Sci. Philad.* 1876, p. 56; *Freshw. Rhiz. N. Amer.* 1879, p. 175, t. xxix.

A rare species which I have only obtained in abundance from the two following localities:—Cocket Moss, near Giggleswick, W. Yorkshire, amongst *Sphagnum* and *Utricularia minor*. Moel Siabod, N. Wales, in *Sphagnum*-pools.

Height of shell 100-145 μ; diameter of shell 100-152 μ.

The mouth of the shell of this Rhizopod is inturned into the cavity of the shell, forming a short, broad, tube-like mouth. Leidy figures the pseudopodia as arising from the body-protoplasm at the inner end of this tube; but in all the living forms observed, a ventral column of protoplasm passed from the body-protoplasm into this tube, completely filling it up to the outer end. The pseudopodia then arose from the extreme ventral surface of this mass of protoplasm in the tube.

16. **Arcella artocrea**, *Leidy, in Proc. Acad. Nat. Sci. Philad.* 1876, p. 57; *Freshw. Rhiz. N. Amer.* 1879, p. 178, t. xxx. ff. 1-9.

Bog above the lakes at Capel Curig, N. Wales.

Very large forms:—Diameter of shell (inclusive of rim) about 300 μ; diameter of mouth 73 μ; height of shell about 110 μ. Leidy gives 176 μ as his greatest breadth. (Pl. 28. fig. 2.)

Churchill, Co. Donegal, Ireland.

Diameter of shell about 85 μ.

I was unable to find any living specimens, all the shells being empty. The body of the shell was faceted, as in many of the more angular forms of *A. vulgaris*. It is apparently a very rare species, as I have never met with it from any other localities.

Gen. Centropyxis, *Stein*.

17. **Centropyxis aculeata**, *Stein, Sitz. böhm. Akad. Wiss.* 1857; *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 180, t. xxxi. ff. 1-32, t. xxxii. ff. 29-37.—Arcella aculeata, *Ehrenb. Abhand. Akad. Wiss. Berlin*, 1830, p. 40; 1841, p. 368, t. iii. f. 5. Echinopyxis aculeata, *Clap. & Lachm. Études Infus.* 1859, p. 447; *Carter, in Ann. Mag. Nat. Hist.* xiii. 1864, p. 29, t. i. f. 8.

This Rhizopod is very abundant and widely distributed, and the shell exhibits more variation than that of any other testaceous form. Some exceptionally large individuals were met with from near Athry Lough, W. Ireland, with a diameter of 450 μ without the spines. It was observed in many varied localities up to 3000 ft. on Snowdon, N. Wales, and 3000 ft. in Scotland.

Although this animal was first described by Ehrenberg as a species of *Arcella*, and is yet regarded as such by some authors, I think there can be no doubt that it bears a closer resemblance to *Difflugia constricta* than to any other testaceous Rhizopod. Leidy points this out most clearly, and gives illustrations of numerous intermediate forms, and Blochmann also comments upon it.

From near Knaresborough and from near Giggleswick, W. Yorkshire, a large number of small examples were seen with the shells composed of sand-grains. The shells were very much oblique, and possessed three smooth, chitinous spines at the fundus, each spine being sharply apiculate. Diameter of shell 63 μ; length of spines 25 μ.

A peculiar form was met with from Widdale Beck, N. Yorkshire, with fourteen spines arranged in an arc, those at the fundus being very short, and those towards the mouth very long. Diameter of shell without spines 190 μ.

Some striking forms were observed from Terrington, N. Yorkshire. The shells were thin, chitinous, and almost transparent. Diameter of shell 120 μ. Three short, thick spines were present, each spine being perforated at the apex. Thus, in addition to the mouth of the shell, there were three open, tubular passages placing the interior of the shell in communication with external surroundings. Owing to the thinness and transparency of the shells, I was enabled to carefully examine the structure of the chitinous membrane of which they were composed. Leidy remarks (*loc. cit.* p. 183) that "while spineless specimens of *Centropyxis*, composed of chitinoid membrane, approximate to *Arcella* in character, I never could satisfy myself that the shell of the former exhibited the cancellated structure of the latter. In some chitinous shells of *Centropyxis* I have observed a punctated appearance of some uniformity, but it did not display the clear cancellated arrangement so characteristic of the shell of *Arcella*."

The chitinous membrane composing the shells of the Terrington forms was of a pale yellow colour and minutely scrobiculate. The scrobiculations were irregularly disposed, being scattered more or less in groups, and between them were numerous much

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smaller punctulations. The structure of the shell-membrane of the particular forms described was thus of a somewhat different nature from the cancellated structure exhibited by the shells of *Arcella*. (*Cfr.* Pl. **29**. figs. 15, 16.)

Var. ECORNIS, *Leidy, l. c.* p. 180, t. xxx. ff. 20–34, t. xxxi. ff. 33, 34.—*Arcella ecornis*, Ehrenb. Abhand. Akad. Wiss. Berlin, 1841, p. 368, t. i. f. 9, t. iii. f. 46. *Centropyxis lævigata*, Penard, in Mém. Soc. Phys. et d'Hist. Nat. Genève, tom. xxxi. no. 2, 1890, p. 151. t. v. ff. 42–44, 49–55.

Not so abundant as the typical spined form. Obtained it very abundantly on damp moss on limestone rocks, Ingleton, N. Yorkshire. Also from near Bowness, Westmoreland.

Gen. DIFFLUGIA, *Leclerc*.

18. DIFFLUGIA CONSTRICTA, *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 120, t. xviii.—Arcella constricta, *Ehrenb. Abhand. Akad. Wiss. Berlin*, 1841, p. 410, t. iv. f. 35, t. v. f. 1. Difflugia marsupiformis, *Wallich, in Ann. Mag. Nat. Hist.* xiii. 1864, pp. 241, 244, t. xvi. ff. 3–5. D. platystoma, *Penard, in Mém. Soc. Phys. et d'Hist. Nat. Genève*, tom. xxxi. no. 2, 1890, p. 143, t. iv. ff. 35–37.

A very abundant species which exhibits much variation, many of the forms being practically indistinguishable from *Centropyxis aculeata* var. *ecornis*. The highest elevation at which I obtained it was 3000 ft. on Snowdon, N. Wales.

19. DIFFLUGIA PYRIFORMIS, *Perty*, 1848; *Kennt. kleinst. Lebensf.* 1852, p. 187, t. ix. f. 9; *Leidy, Freshw. Rhiz. N. Amer.* 1879, t. x., xi., xii. ff. 1–18, etc.—D. compressa, *Carter, in Ann. Mag. Nat. Hist.* xiii. 1864, p. 22, t. i. ff. 5, 6. D. entochloris, *Leidy, in Proc. Acad. Nat. Sci. Philad.* 1874, p. 79; 1875, p. 307. D. saxicola, *Penard, in Mém. Soc. Phys. et d'Hist. Nat. Genève*, tom. xxxi. no. 2, 1890, p. 138, t. iii. ff. 50–53. D. avellana, *Penard, l. c.* p. 144, t. iv. ff. 38–40. D. fallax, *Penard, l. c.* t. iv. ff. 41–51. D. lucida, *Penard, l. c.* p. 145, t. iv. ff. 52–58. D. bacillifera, *Penard, et* var. inflata, *Penard, l. c.* p. 46, t. iv. ff. 61–71. D. lanceolata, *Penard, l. c.* p. 145, t. iv. ff. 59, 60.

The most widely distributed species of the genus, especially in quiet waters. It is subject to very great variation, not only in outward form, but also in the nature of the materials composing the shell. Only once have I obtained it from wet rocks, and that was at an elevation of 3000 ft. on Snowdon, N. Wales.

The three following are the most noteworthy forms I have met with:—

From a bog near Widdale Beck, N. Yorkshire, numerous large specimens were noticed with thin chitinoid shells with which were incorporated very large Diatoms (*Navicula viridis* and *N. major*). Precisely similar forms were noticed in which the shells consisted almost entirely of Diatoms (*Vanheurckia rhomboides* and *Navicula divergens*) from near Clapham, W. Yorkshire, and from Mickle Fell, N. Yorkshire.

From Lough Shannacloontippen and Ballynahinch, W. Ireland, numbers of minute forms of this Rhizopod were observed. The shell was chitinoid, of a pale yellow colour, and a few sand-grains were attached irregularly at the fundus. The same form was noticed from Capel Curig, N. Wales, except that the chitinous shell was colourless. Length of shell 29–30 μ; breadth 18–24 μ. (Pl. **28.** figs. 13, 14.)

From Llyn Idwal, N. Wales, the forms possessed long slender necks, and the shell was composed of exceptionally large sand-grains. The same form was also obtained from Cockett Moss, near Giggleswick, W. Yorkshire. Length of shell about 250 μ; breadth 46 μ.

Var. VAS, *Leidy*, Freshw. Rhiz. N. Amer. 1879, p. 99, t. xii. ff. 2–9.—*D. vas*, Leidy, in Proc. Acad. Nat. Sci. Philad. 1874, p. 155; 1875, p. 307.

Not uncommon, but rarely so abundant as more typical forms of *D. pyriformis*. The peculiar neck of this variety is very characteristic.

The largest forms seen were from the New Forest, Hants. Length of shell 470 μ; breadth 380 μ; breadth of neck 100 μ.

Some peculiar forms were seen from Llyn Idwal, N. Wales, in which the sand-grains composing the neck were quite transparent and colourless, whereas those composing the body of the shell were yellow and opaque. Length 460 μ; breadth 300 μ.

20. DIFFLUGIA URCEOLATA, *Carter, in Ann. Mag. Nat. Hist.* xiii. 1864, pp. 27, 37, t. i. f. 7; *Leidy, l. c.* p. 106, t. xiv.—D. lageniformis, *Wallich, in Ann. Mag. Nat. Hist.* xiii. 1864, p. 240, t. xiv. ff. 15, 16.

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A rare species, which I have only obtained copiously from Bowness, Westmoreland.

21. Difflugia acuminata, *Ehrenb. Infus.* 1838, p. 131, t. ix. f. 3; *Leidy, l. c.* p. 109, t. xiii.—D. bacillariarum, *Perty*.

An abundant and widely distributed species, which I have observed up to 2200 ft. on Glyder Fach, N. Wales.

Var. amphora.—*D. amphora*, Penard, in Mém. Soc. Phys. et d'Hist. Nat. Genève, tom. xxxi. no. 2, 1890, p. 139, t. iii. ff. 55–65. Not *D. amphora*, Leidy (which is a variety of *D. urceolata*).

Differs from typical *D. acuminata* in the upper portion of the shell being acutely conical but not acuminate.

This variety frequently possesses a shell consisting of a thin chitinous membrane incorporated with Diatoms. *Cfr.* Leidy, *l. c.* t. xiii. ff. 23–26. Such forms were very abundant from Cocket Moss, near Giggleswick, W. Yorkshire, and in all cases the Diatom was *Vanheurckia rhomboides* var. *saxonica*.

Var. elegans.—*D. elegans*, Penard, *l. c.* p. 140, t. iv. ff. 4–11.

A small variety with the acuminate apex of the shell tube-like and perforated. Length of shell 94–100 μ; breadth of shell 52–58 μ; breadth of mouth 27–31 μ. (Pl. 28. figs. 11–12.)

Wicken Fen, Cambridgeshire. Llyn-y-cwm-ffynon, N. Wales.

The shells of this variety are generally chitinous, pale yellow or brown in colour, and they may or may not be encrusted with a variable amount of sand-grains. The body of the animal is quite normal, and is supported towards the apex of the shell by the usual, protoplasmic, stay-like projections. The actual apex of the shell is drawn out into a long tube, which is frequently bent at a considerable angle to one side, and the end of this tube is open. I have never observed any exudation of protoplasm into this tube, the body of the animal being somewhat removed from its base. As the shell possesses two openings, one at each end, it is quite comparable to shells like *Ditrema* and *Amphitrema*, which are placed in the family *Amphistomina*, although in the *Difflugia* only one aperture is utilized for the protrusion of pseudopodia.

Occasionally a few Diatoms are incorporated into the shell, and one instance was noticed in which a number of living Diatoms were attached to it.

22. Difflugia corona, *Wallich, in Ann. Mag. Nat. Hist.* 1864, xiii. t. xv. ff. 19, 20; *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 117, t. xvii.

A rare species which I have only observed from Llyn Llydaw, Snowdon, and in pools, Y Foel Fras, N. Wales. In all the specimens observed the spines were very robust. Length of shell 150–160 μ; breadth (including spines) 165–182 μ; breadth of mouth 75 μ.

23. Difflugia globulosa, *Dujardin, in Ann. Sci. Nat.* 1837, viii. p. 311, t. ix. f. 1 *a*, *b*; *Leidy, l. c.* p. 96, t. xv. ff. 25–31; t. xvi. ff. 1–24. D. globularis, *Wallich, in Ann. Mag. Nat. Hist.* xiii. 1864, p. 241, t. xvi. ff. 1, 2, 17, 27. D. acropodia, *Hertwig & Lesser, in Archiv für mikr. Anat.* 1874, x. Suppl. p. 107, t. ii. f. 6.

A general and widely distributed species, exhibiting considerable variation in size and form. I have obtained it at 2700 ft. on Glyder Fawr, and at 3000 ft. on Snowdon, N. Wales.

The smallest forms observed were from Roundhay Park, W. Yorkshire. The shells were straw-coloured and slightly asperulate; diam. 13·5–17 μ; diam. of mouth 5·7 μ. (Pl. 29. figs. 17, 18.)

Another small form, which was abundant from Lough Guitane and Torc Mt., S.W. Ireland, possessed a yellow, chitinous shell with an exceptionally wide mouth. Diam. 38 μ; diam. of mouth 29–33 μ.

Two specimens were observed conjugating from Cocket Moss, near Giggleswick, W. Yorkshire. From this locality the animals possessed a perfectly globose, colourless chitinous shell, attached to which were a few sand-grains and numerous large Diatoms. The mouth was relatively very small. Diam. 190 μ; diam. of mouth 52 μ.

24. Difflugia lobostoma, *Leidy, in Proc. Acad. Nat. Sci. Philad.* 1874, p. 79; 1877, p. 307; *Freshw. Rhiz. N. Amer.* 1879, p. 112, t. xv. ff. 1–24, t. xvi. ff. 25–29.—D. crenulata, *Leidy*, 1874.

Somewhat scarce. Diameter of shell 49–285 μ.

Form with a three-lobed mouth observed from Carlton Bank, N. Yorkshire; Llyn Cwlyd and Capel Curig, N. Wales.

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Form with a five-lobed mouth observed from near Sedbergh, W. Yorkshire. These specimens were very much larger than any previously recorded.

Gen. LECQUEREUSIA, *Schlumberger*.

25. LECQUEREUSIA SPIRALIS, *Blochmann, Die mikr. Thierwelt des Süsswass.*, I. *Protozoa, Hamburg*, 1895, p. 17.—Difflugia spiralis, *Ehrenb.* 1840; *Abhand. Akad. Wiss. Berlin*, 1871, p. 274, t. iii. ff. 25–27; *Pritch. Infus.* 1861, p. 553. Lecquereusia jurassica, *Schlumb. in Ann. Sci. Nat.* 1845, p. 255. Difflugia Helix, *Cohn, in Zeitschr. f. wissensch. Zool.* 1853, p. 261.

Generally distributed and abundant. The amount of coiling of the shell and the nature of the materials composing it vary considerably. The forms possessing a shell composed entirely of sand-grains are somewhat rare.

Gen. NEBELA, *Leidy*.

26. NEBELA COLLARIS, *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 145, t. xxii.; t. xxiii. ff. 1–7; t. xxiv. ff. 11, 12.—Difflugia collaris, *Ehrenb. Monatsb. Akad. Wiss. Berlin*, 1848, p. 218. D. peltigeracea, *Carter, in Ann. Mag. Nat. Hist.* xiii. 1864, t. i. f. 12. D. symmetrica, *Wallich, in Ann. Mag. Nat. Hist.* xiii. 1864, t. xvi. ff. 27–33. Nebela militaris, *Penard, in Mém. Soc. Phys. et d'Hist. Nat. Genève*, tom. xxxi. no. 2, 1890, p. 164, t. vii. ff. 16–22.

Widely distributed, especially in *Sphagnum*-bogs. Up to 2000 ft. on Glyder Fach, and 2700 ft. on Glyder Fawr, N. Wales. In *Sphagnum*-pools, Orkney Is.

Var. LAGENIFORMIS.—*N. lageniformis*, Penard, l. c. p. 158, t. vi. ff. 50–61. *N. ambigua*, Cash, in Trans. Manchester Micr. Soc. 1891, p. 50, t. ii. f. 17.

This variety is distinguished by its more elegant outline and prominent neck. In habit, structure of shell, etc. it is precisely similar to typical *N. collaris*. Length of shell 115–123 μ; breadth of shell 63–70 μ; breadth of mouth 25–27 μ.

A less frequent form than the type, and one which I have only obtained in quantity from pools on Penyghent, W. Yorkshire, and from Capel Curig, N. Wales.

27. **NEBELA FLABELLULUM**, *Leidy, in Proc. Acad. Nat. Sci. Philad.* 1876, p. 118, ff. 6, 7; 1877, p. 264; *Freshw. Rhiz. N. Amer.* 1879, p. 152, t. xxiii. ff. 8–19.

Not so abundant as the preceding species; often found amongst mosses on dripping rocks. Up to 2700 ft. on Glyder Fawr N. Wales.

28. **NEBELA DENTISTOMA**, *Penard, in Mém. Soc. Phys. et d'Hist. Nat. Genève*, tom. xxxi. no. 2, 1890, p. 162, t. vi. ff. 98–100; t. vii. ff. 1–5.—N. crenulata, *Cash, in Trans. Manchester Micr. Soc.* 1891, p. 50, t. ii. f. 18.

Length of shell 108–113 μ; max. breadth of shell 82–88 μ; breadth of mouth 36–38 μ; thickness 42 μ.

Amongst *Philontis fontana* in springs at 2700 ft. on Glyder Fawr, N. Wales.

This species, which is either rare or overlooked, is completely different in outward form from *N. collaris*, the only species with which it could be confounded. Except for the mouth, it is a perfect oval in shape, and that orifice appears as a chord cutting off the narrower end. There is not even the faintest suspicion of a neck, and the mouth is considerably wider than in any form of *N. collaris*. The specific name refers to the nature of the mouth, and therein lies the character which at once distinguishes *N. dentistoma* from *N. collaris*. The mouth of the shell of the former species always presents a crenulate appearance, owing to the irregular disposition of the small plates composing the shell, whereas the mouth of the latter species is perfectly smooth and sometimes slightly thickened. The ratio of the breadth of the mouth to the breadth of the shell in *N. dentistoma* averages 1 : 2·3, whereas in *N. collaris* it averages 1 : 2·8.

29. **NEBELA CARINATA**, *Leidy, in Proc. Acad. Nat. Sci. Philad.* 1876, p. 118, ff. 10, 11; *Freshw. Rhiz. N. Amer.* 1879, p. 154, t. xxiv. ff. 1–10.—Difflugia carinata, *Archer*, 1866; *in Qu. Jour. Micr. Sci.* 1869, ix. t. xx. f. 12.

Although widely distributed this species is not abundant. It is usually found amongst *Sphagnum*. I obtained numerous examples from some deep *Sphagnum*-pools at 2200 ft. on Glyder Fach, N. Wales.

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30. **Nebela hippocrepis**, *Leidy*, *Rhiz. N. Amer.* 1879, p. 156, t. xxv. ff. 9–14.

Length of shell 183 μ; breadth 133 μ; breadth of mouth 29 μ.

Amongst wet *Sphagnum* below the outlet of Llyn Idwal, N. Wales.

Only one specimen of this rare species was observed, and it was an old, empty shell. The digitate processes of the carina which pass down into the cavity of the shell are unique and unmistakable. It has only previously been found in New Jersey.

Blochmann suggests that it is the same species as *N. bigibbosa*, Penard, but on careful comparison the two shells are seen to be of quite a different nature, *N. bigibbosa* being entirely devoid of a keel. A species which may, however, ultimately prove to be *N. hippocrepis* is *N. galeata*, Penard, but Penard's figures are too indistinct for one to form any definite opinion.

31. **Nebela barbata**, *Leidy*, *in Proc. Acad. Nat. Sci. Philad.* 1876, p. 119, f. 8; *Freshw. Rhiz. N. Amer.* 1879, p. 159, t. xxiv. ff. 14–17.

Llyn Llydaw, Snowdon, N. Wales. A number of minute sand-grains were attached to the shell. Length 198 μ; breadth 50 μ; length of spines about 15 μ.

Gen. Heleopera, *Leidy*.

32. **Heleopera picta**, *Leidy*, *Freshw. Rhiz. N. Amer.* 1879, p. 162, t. xxxi. ff. 1–11.—Difflugia sphagni, *Leidy*, 1874. Nebela sphagni, *Leidy*, 1876.

Not uncommon in *Sphagnum*-pools and bogs. Frequently met with in the encysted condition.

33. **Heleopera petricola**, *Leidy*, *l. c.* p. 165, t. xxvi. ff. 12–20.

A much scarcer species than *H. picta*. Bog near Widdale Beck, N. Yorkshire. Hawkshead, Lancashire. Capel Curig, N. Wales. Near Glenties, Co. Donegal, Ireland. Orkney Is.

Gen. Quadrula, *F. E. Schulze*.

34. **Quadrula symmetrica**, *F. E. Schulze*, *in Archiv für mikr. Anat.* 1875, p. 329, t. xviii. ff. 1–6; *Archer*, *in Qu. Jour. Micr. Sci.* 1877, p. 122.—Difflugia symmetrica, *Wallich*, *in Ann. Mag. Nat. Hist.* xiii. 1864, p. 245. D. assulata, *Ehrenb* 1871.

Widely distributed, but rarely abundant. Not uncommon amongst *Sphagnum* in peaty pools and bogs; also amongst mosses on wet rocks.

I have noticed a small form of this animal in which the oral end of the shell is produced into a neck of considerable length. The chitinous plates composing the shell are also polygonal in form and more numerous. Length of shell 63–68 μ; breadth of shell 28–33 μ; breadth of neck 10–14 μ. Bowness, Westmoreland, and Moel Siabod, N. Wales.

35. QUADRULA IRREGULARIS, *Archer*, *in Qu. Jour. Micr. Sci.* xvii. 1877, p. 113.—Q. monensis, *Cash*, *in Trans. Manchester Micr. Soc.* 1891, p. 50, t. ii. ff. 14–16.

Among mosses in a mountain-stream, Penyghent, W. Yorkshire. Length of shell 35 μ; breadth of shell 36 μ; breadth of mouth 13 μ; thickness 23 μ. (Pl. 29. figs. 19, 20.)

Not more than two or three specimens of this interesting species were observed, but the shell is so characteristic and its aspect so different from that of *Q. symmetrica*, that it is impossible to confuse them. The plates composing the shell (or test) were comparatively regular in outline and arrangement, being approximately square and more or less arranged in oblique series. It agrees very well with Archer's description in being "smaller than *Q. symmetrica*, quite without any neck, the 'mouth' being where a small chord seems, as it were, cut off the globular, or perhaps somewhat compressed test, nor are there any 'lips' nor even any evident thickened margin." Archer states that the plates composing the test are arranged in longitudinal rows, but in the few specimens observed the rows of plates were slightly oblique. He also says: "mouth subcircular in outline," whereas the mouth of the Yorkshire specimens was almost narrowly elliptical. This fact is immaterial, however, if the usual allowance be made for the variation which is so striking a feature of the testaceous Rhizopods. The specimens observed were undoubtedly identical with *Q. monensis*, and, moreover, they also agreed with Cash's description in possessing an elliptical mouth and obliquely disposed plates. But as I am firmly convinced that *Q. monensis* is the same species of Rhizopod as that named *Q. irregularis* by Archer nineteen years previously, the latter name takes precedence.

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Gen. HYALOSPHENIA, *Stein.*

36. HYALOSPHENIA CUNEATA, *Stein, Sitzungsb. böhm. Akad. Wiss.* 1857; *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 129, t. xx. ff. 1-10.—H. lata, *Schulze, in Archiv für mikr. Anat.* 1875, xi. p. 335, t. xviii. ff. 15-18; *Archer, in Qu. Jour. Micr. Sci.* 1877, p. 110.

Cocket Moss, near Giggleswick, W. Yorkshire. Large specimens with a relatively broad mouth to the shell. Length of shell 75 μ; breadth of shell 60 μ; breadth of mouth 31 μ.

River Ballanderry near its entrance into Lough Neagh, Ireland. Small specimens with a faint indication of a neck to the shell, the mouth of which is relatively small. Numbers of specimens were examined in a very active state, and each possessed two contractile vacuoles. The nucleus in these Irish specimens was comparatively small. Length of shell 56-62 μ; breadth 40-44 μ; breadth of mouth 13-14 μ; thickness 16 μ. (Pl. 29. figs. 21, 22.)

37. HYALOSPHENIA ELEGANS, *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 140, t. xx. ff. 19-29.—Difflugia (Catharia) elegans, *Leidy, in Proc. Acad. Nat. Sci. Philad.* 1874, p. 156.

This species I have only observed among *Sphagnum* at Cocket Moss, near Giggleswick, W. Yorkshire.

LEPTOCHLAMYS, gen. n.

Shell ovoid, slightly oblique, consisting of a thin, transparent, structureless, chitinoid membrane; narrower or ventral end of shell slightly produced and minutely expanded, terminating in a mouth which is often placed a little obliquely; vertical view of shell circular; mouth circular. Protoplasmic body completely filling the shell; nucleus very large and situated dorsally. With a single, short pseudopodium, broadly expanded and sometimes cordate. Vacuoles entirely absent.

38. LEPTOCHLAMYS AMPULLACEA, sp. unica. (Pl. 29. figs. 23-26.)

Small; body composed of finely granular protoplasm, containing a large punctate nucleus at the pole away from the mouth; both green and brown food-particles present in the body-protoplasm. With a single pseudopodium (sometimes a faint indication of two), well differentiated into a lobe of dull grey endoplasm enveloped in a larger mass of clear transparent ectoplasm.

Length of shell 48–55 μ; diameter of shell 36–40 μ; diameter of mouth 15–17 μ.

This interesting Rhizopod was abundant among various Algæ and *Isoëtes*, in the shallow water at the margins of Llyn-y-cwm-ffynon, Glyder Fawr, N. Wales.

The structureless shell at first reminds one of *Hyalosphenia*, but, apart from the entirely different nature of the animal, the shell is at once distinguished from shells of that genus by its circular cross-section and circular mouth. It is a thin, transparent, chitinoid shell, generally somewhat obliquely ovoidal (or ellipsoidal), and possesses a slightly expanded, minutely bell-shaped mouth at the narrower or ventral pole. The shell is quite firm and rigid, and the body-protoplasm of the animal completely fills it, fitting closely to the inner surface.

The nucleus, which, as compared with that of other lobose Rhizopods, is exceedingly large, is situated towards the extreme dorsal pole of the shell, and exhibits a finely punctate appearance. The body-protoplasm is of a dull grey colour, and is filled with granules of variable magnitude, more especially in the region immediately ventral to the nucleus. Various food-particles in different stages of digestion are noticeable in almost every individual, the animals feeding largely on unicellular Palmellaceæ. The method of feeding is quite normal.

One of the most remarkable features of *Leptochlamys* is the extraordinary pseudopodium. On the protrusion of the pseudopodium the animal first exudes from the mouth of the shell a more or less globular mass of ectoplasm, which is transparent and very hyaline in appearance. This is followed by an exudation of slightly darker-coloured, homogeneous endoplasm. The pseudopodium is quite a large mass, ever changing its shape, but never at any time becoming divided into two pseudopodia. At most, it becomes retuse at the broad, distal end, and at all times there is a well-marked separation into ectoplasm and endoplasm.

No vacuoles (contractile or otherwise) were observed in any of the animals, and so far as I could ascertain they were absent.

The genus is undoubtedly nearest to *Cryptodifflugia*, Penard (in Mém. Soc. Phys. et d'Hist. Nat. Genève, tom. xxxi. no. 2, 1890, p. 168, t. vii. ff. 95–107), but is readily distinguished by

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the different mouth of the shell, and the nature of the animal and its pseudopodia.

Fam. EUGLYPHINA.

Gen. EUGLYPHA, *Dujardin.*

39. EUGLYPHA ALVEOLATA, *Dujardin, Infusoires*, 1841, p. 252, t. ii. ff. 9, 10; *Hertwig & Lesser, in Archiv für mikr. Anat.* 1874, x. Suppl. p. 124, t. iii. f. 5; *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 207, t. xxxv. ff. 1–18.—Difflugia areolata, *Ehrenb.* D. acanthophora, *Ehrenb.* Euglypha tuberculata, *Duj.* E. lævis, *Perty.* E. minima, *Perty.*

Generally distributed and often abundant. Very variable in the form of the shell and in the plates composing it. The young forms were described by Perty as *E. lævis* and *E. minima.*

Some very large forms were noticed from Puttenham Common, Surrey; there were four strong spines in the dorsal region of the shell. Length of shell 154 μ; breadth 80 μ.

It was obtained abundantly at 2700 ft. on Glyder Fawr, N. Wales.

40. EUGLYPHA CILIATA, *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 214, t. xxxv. ff. 19, 20; t. xxxvi.; t. xxxvii. ff. 30, 31.—Difflugia ciliata, *Ehrenb. Monatsb. Akad. Wiss. Berlin*, 1848, p. 379. Euglypha compressa, *Carter, in Ann. Mag. Nat. Hist.* 1864, xiii. p. 32, t. i. f. 13; *Schulze, in Archiv für mikr. Anat.* 1875, xi. p. 101, t. v. ff. 3, 4.

Generally distributed, but not so abundant as the preceding species. The forms noticed with the largest spines were from the New Forest, Hants. It was obtained at 2700 ft. on Glyder Fawr, N. Wales, and conjugating examples were observed from Moel Siabod, N. Wales.

Var. STRIGOSA.—*Difflugia strigosa*, Ehrenb. *Euglypha strigosa*, Leidy, in Proc. Acad. Nat. Sci. Philad. 1878, p. 172; Penard, in Mém. Soc. Phys. et d'Hist. Nat. Genève, tom. xxxi. no. 2, 1890, p. 179, t. ix. ff. 58–68.

I have only occasionally met with the forms with more or less diffuse, hair-like spines, which are included in this variety. Bowness, Westmoreland. Bog near Widdale Beck, N. Yorkshire. Richmond Park, Surrey. Llyn Ogwen, N. Wales. Orkney Is.

41. **Euglypha mucronata**, *Leidy, in Proc. Acad. Nat. Sci. Philad.* 1878, p. 172; *Freshw. Rhiz. N. Amer.* 1879, p. 219, t. xxxvii. ff. 11–14.

A rare species, which I have only met with amongst *Sphagnum* at Hawkshead, Lancashire.

One specimen was noticed in which there were two spines, one at the extreme apex, and the other some little distance below it. Length of shell (without spine) 123 μ; breadth 60 μ.

42. **Euglypha brachiata**, *Leidy, in Proc. Acad. Nat. Sci. Philad.* 1878, p. 172; *Freshw. Rhiz. N. Amer.* 1879, p. 200, t. xxxvii. ff. 5–10.

Capel Curig, N. Wales. Small lakes E. of Recess, W. Ireland. Length of shell about 120 μ; breadth about 32 μ.

This is another rare species of the genus, which I have only obtained twice, and in both instances from submerged *Sphagnum*. It was described by Leidy from New Jersey.

Gen. Placocysta, *Leidy*.

43. **Placocysta spinosa**, *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 221, t. xxxviii.—Euglypha spinosa, *Carter, in Ann. Mag. Nat. Hist.* 1865, xv. p. 290, t. xii. f. 13; *Archer, in Qu. Jour. Micr. Sci.* 1872, xii. p. 90.

Somewhat rare. Length of shell 120–127 μ; breadth 96–100 μ; breadth of mouth 50–54 μ; thickness about 38 μ.

Scarce in a bog near Bowness, Westmoreland. Hawkshead, Lancashire. Llyn Llydaw, Snowdon, N. Wales: dead shells not uncommon, but no living animals seen. It is recorded as occurring in N. Wales in Qu. Jour. Micr. Sci. 1876, xvi. p. 237, but described as "very rare indeed."

The form of the shell and the wide mouth with perfectly smooth edges are characters sufficient to distinguish this genus from *Euglypha*.

Gen. Sphenoderia, *Schlumberger*.

44. **Sphenoderia lenta**, *Schlumberger, in Ann. Sci. Nat.* 1845, p. 256; *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 229, t. xxxiv. ff. 25–41.—Euglypha globosa, *Carter, in Ann. Mag. Nat. Hist.* 1865, xv. p. 290, t. xii. f. 14; *Hertwig & Lesser, in Archiv für mikr. Anat.* 1874, x. Suppl. p. 129, t. iii. f. 7.

Generally distributed throughout the British Islands. The

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largest forms observed were from Wrynose, Lancashire. Length of shell 65 μ; diameter of shell 54 μ.

Var. FISSIROSTRA.—*Sphenoderia fissirostris*, Penard, in Mém. Soc. Phys. et d'Hist. Nat. Genève, tom. xxxi. no. 2, 1890, p. 184, t. x. ff. 30–40.

Body of shell elliptic-ovoid; plates near the fundus round, but larger and elliptical towards the mouth. Length of shell 46 μ; breadth 23 μ; diameter of mouth 13·5 μ. Llyn Bochlwyd, N. Wales. Orkney Is.

The only difference between this form and typical *Sphenoderia lenta* is the presence of the larger, elliptical plates near the mouth, and this is insufficient as a specific distinction.

The genus *Sphenoderia* is not recognized by Blochmann (Die mikr. Thierwelt des Süsswass., I. Protozoa, Hamburg, 1895, p. 18), who merges it with the genus *Euglypha*. Personally, I think the narrow chitinous mouth, which is quite devoid of the plates of which the remainder of the shell is composed, is a very good generic character, and one which at once distinguishes *Sphenoderia* from *Euglypha*.

Gen. ASSULINA, *Ehrenb.*

45. ASSULINA SEMINULUM, *Ehrenb.* 1871; *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 225, t. xxxvii. ff. 15–27.—Difflugia seminulum, *Ehrenb. Monatsb. Akad. Wiss.* 1848, p. 379. Euglypha brunnea, *Leidy*, 1874. E. tincta, *Archer*, 1875.

General amongst *Sphagnum* and on wet rocks. Up to 3500 ft. on Lochnagar, Scotland. Orkney Is.

Gen. TRINEMA, *Dujardin.*

46. TRINEMA ENCHELYS, *Leidy, in Proc. Acad. Nat. Sci. Philad.* 1878, p. 172; *Freshw. Rhiz. N. Amer.* 1879, p. 227, t. xxxix.—Difflugia enchelys, *Ehrenb. Infus.* 1838, p. 132, t. ix. f. 4. Arcella hyalina, *Ehrenb.* Trinema acinus, *Dujardin*, *Infusoires*, 1841, p. 249, t. iv. f. 1. Trinema complanatum, *Penard.* T. lineare, *Penard.*

Probably the commonest and most widely distributed of testaceous Rhizopods, occurring abundantly in all kinds of damp and wet situations. The largest forms noticed were from Mickle Fell, N. Yorkshire, and it was observed up to 2700 ft. on Glyder Fawr, N. Wales.

Gen. CYPHODERIA, *Schlumberger*.

47. CYPHODERIA AMPULLA, *Leidy*, *in Proc. Acad. Nat. Sci. Philad.* 1878, p. 173; *Freshw. Rhiz. N. Amer.* 1879, p. 202, t. xxxiv. ff. 1–16.—Difflugia ampulla, *Ehrenb.* 1840; *Abhandl. Akad. Wiss.* 1871, t. iii. f. 11. Cyphoderia margaritacea, *Schlumberger*, *in Ann. Sci. Nat.* 1845, iii. p. 255; *Hertwig & Lesser*, *in Archiv für mikr. Anat.* 1874, x. Suppl. p. 132. Euglypha curvata, *Perty*. E. margaritacea, *Wallich*. Cyphoderia margaritacea, *var.* major, *Penard*.

General and abundant. The largest specimens observed were equal in size to those described by Penard as var. *major*, and were obtained from Stavely Dam, near Knaresborough, W. Yorkshire. Length up to 165 μ; breadth 66 μ. It was obtained at over 3000 ft. elevation on Snowdon, N. Wales.

The form with the prominent mamillate process at the fundus was noticed from Wicken Fen, Cambs., and from Lough Neagh, Ireland.

From Llyn Idwal, N. Wales, many active animals were noticed in which the body-protoplasm had retreated from the thick end of the shell, leaving a large space, but no strands of protoplasm stretched across this space from the body-protoplasm to the shell as in *Arcellas* and *Hyalosphenias*.

From Bowness, Westmoreland, numerous small specimens were observed with an apparently homogeneous, deep-brown shell, which was asperulate on its outer surface. The neck was also more pronounced and bent than in any other specimens I have seen. Length of shell 81–87 μ; breadth 28–31 μ.

Fam. GROMIINA.

Gen. PSEUDODIFFLUGIA, *Schlumberger*.

48. PSEUDODIFFLUGIA GRACILIS, *Schlumberger*, *in Ann. Sci. Nat.* 1845, iii. p. 254; *Leidy*, *Freshw. Rhiz. N. Amer.* 1879, p. 198, t. xxxiii. ff. 18–28.—Pleurophrys sphærica, *Clap. et Lachm.* 1859. Pleurophrys ? amphitrematoides, *Archer*.

Somewhat scarce and liable to be overlooked.

Capel Curig, N. Wales, amongst *Sphagnum*. Also near the outlet of Llyn Bochlwyd, N. Wales.

Gen. PAMPHAGUS, *Bailey*.

49. PAMPHAGUS HYALINUS, *Leidy*, *Freshw. Rhiz. N. Amer.* 1879, p. 194, t. xxxiii. ff. 13–17.—Arcella ? hyalina, *Ehrenb.*

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1838. Gromia hyalina, *Schlumberger*, 1845. Lecythium hyalinum, *Hertwig & Lesser, in Archiv für mikr. Anat.* 1874, x. Suppl. p. 177, t. iii. f. 8.

Not uncommon in ponds and lakes. Observed most abundantly from ponds, Cirencester, Gloucestershire, among *Potamogetons*. Also abundant among *Isoëtes*, Llyn Idwal, N. Wales. Diam. 32–38 μ.

50. **Pamphagus curvus**, *Leidy, l. c.* p. 196, t. xxxiii. ff. 11, 12.

The specimens were obtained from amongst mosses on wet rocks at over 3000 ft. elevation on Snowdon, N. Wales. They agreed very well with the animals described by Leidy, but were somewhat larger. Length 59–76 μ; greatest breadth 32–36 μ. (Pl. 29. fig. 27.)

The vertical aspect of the animal was circular, and the pseudopodia, which were much branched, exhibited somewhat active movements. The animals were all feeding upon a small species of *Nitzschia*, individuals being observed in which the whole body, inside the thin, hyaline shell, was packed with the valves of this Diatom.

Gen. Gromia, *Dujardin*.

51. **Gromia stagnalis**, sp. n. (Pl. 29. fig. 28.)

Body small, perfectly spherical, usually green in colour. Shell chitinoid, spherical, colourless or straw-coloured, very thin and transparent, smooth on its external surface. Mouth small, not readily visible. A large amount of protoplasm is exuded from the mouth, flowing all over the exterior of the shell, and giving rise to numerous, divergent and anastomosing pseudopodia. Nucleus small, often not visible, situated in the region away from the mouth.

Diameter of body 28–32 μ.

Among *Lemna minor* in stagnant ditches, near Brigg, Lincolnshire.

This beautiful Rhizopod occurred in abundance in the sediment collected by washing and squeezing *Lemna minor* and a few species of filamentous algæ. The only other freshwater species of *Gromia* are *G. fluviatilis*, Dujardin (in Ann. Sci. Nat. sér. 2, tom. viii., Zool. pp. 310–313), and *G. terricola*, Leidy (in Proc. Acad. Nat. Sci. Philad. 1874, p. 88; Freshw. Rhiz. N. Amer. 1879, p. 277, t. xlvii. ff. 1–4). From both of these species *G. stagnalis* is readily distinguished by its small size, green colour, and habit. *G. fluviatilis*, Duj., was found among *Potamogeton* in the R. Seine, and has an oval shell of much larger size. *G. terricola*, Leidy, occurs on the ground amongst moist mosses, and is also a much larger animal.

A species found amongst *Ceratophyllum* and other water-plants, and described as *G. granulata* by Schulze (in Archiv für mikr. Anat. 1875, xi. p. 117, t. vi. ff. 5, 6), appears to me to be hardly distinguishable from *G. fluviatilis*, Duj.

The green colour of *G. stagnalis* is due to the presence of more or less diffuse chlorophyll in the protoplasm of the body. This has most likely been acquired by the animal whilst feeding on the numerous small green algæ with which it was associated. The protoplasm, which is poured out from the mouth of the shell in quantity, has a dull and somewhat translucent appearance, and exhibits no visible granulation. Nor is a continuous streaming movement to be observed in the pseudopodia, the general movements of which are very slow.

Fam. AMPHISTOMINA.

Gen. DIPLOPHRYS, *Barker*.

52. DIPLOPHRYS ARCHERII, *Barker, in Qu. Jour. Micr. Sci.* 1868, p. 123; *Hertwig & Lesser, in Archiv für mikr. Anat.* 1874, x. Suppl. p. 139, t. iii. f. 9.

In stagnant ditches, near Brigg, Lincolnshire. In bog-pools, Thursley Common, Surrey. Lough Gatny, Co. Donegal, Ireland.

All the specimens observed were small in size, and without exception were solitary individuals. The average diameter of the body was 14 μ.

Gen. AMPHITREMA, *Archer*.

53. AMPHITREMA WRIGHTIANUM, *Archer, in Qu. Jour. Micr. Sci.* 1867, vii. p. 4; 1870, x. p. 122, t. xx. ff. 4, 5.

This is evidently a rare species of Rhizopod. I have only obtained it once, from Llyn Llydaw, Snowdon, N. Wales. Length of shell 60 μ; diameter of shell 36 μ.

Some shells of an amphistomous Rhizopod were observed from near Recess, W. Ireland, which probably pertained to this genus. The shells were chitinoid, yellow in colour, and each aperture was situated on a slight protuberance. No living animals of this form were observed.

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Order VAMPYRELLIDA.

Gen. Vampyrella, *Cienkowski.*

54. Vampyrella lateritia, *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 253, t. xlv. ff. 10–16.—Amœba lateritia, *Fresenius,* 1856–8. Vampyrella Spirogyræ, *Cienk. in Archiv für mikr. Anat.* i. 1865, p. 218, tt. xii–xiii. ff. 44–56; *Hertwig & Lesser, in Archiv für mikr. Anat.* 1874, x. Suppl. p. 61, t. ii. f. 2.

Near Brigg, Lincolnshire. Diameter of animal without pseudopodia 23–32 μ; diameter inclusive of long pseudopodia 67–77 μ. (Pl. 29. figs. 29–31.)

The Heliozoön-like form was abundant in a ditch amongst *Lemna minor.* The body of the animal was rarely globular, generally being ellipsoidal or even oblong. Outside the bright red, pigmented mass was a zone of clear protoplasm from which radiated a number of delicate pseudopodia of considerable length. Between the bases of these delicate pseudopodia the clear zone also gave origin to a number of much shorter, thicker pseudopodia, which, although only capable of comparatively slow movements, were extended or retracted more quickly than the elongate, delicate, protoplasmic filaments.

I was sufficiently fortunate to observe several of these animals feeding on the cell-contents of a species of *Mougeotia.* They have frequently been described as feeding on *Spirogyra,* but I know of no recorded instance of a species of this genus attacking a filament of *Mougeotia.* The animal attached itself firmly to the lateral margin of one of the cells of the filament, and in a very short time the long, delicate pseudopodia were retracted. At the same time the clear, outer, protoplasmic zone was continually putting forth and retracting shorter and stouter pseudopodia. That portion of the animal which originally attached itself to the cell *very soon had perforated it,* a portion of the animal protoplasm passing into the cell and causing a violent, dancing movement of the granules of the vegetable protoplasm. Whilst this was happening the chromatophore of the *Mougeotia*-cell was observed to be disintegrating at a point immediately opposite the place of attachment of the animal. I watched this destruction go on for about two hours; it was accompanied by much violent movement on the part of the small granules of the protoplasm, but during that time only a portion of the

Species of

chromatophore and surrounding protoplasm of the vegetable cell had been absorbed by the *Vampyrella*.

It has been stated by some authors that *Vampyrella* does not perforate the cells of *Spirogyra* and other filamentous algæ on which it feeds, but attacks them and devours their contents by breaking the filaments at the joints. It is possible that it does so sometimes, but Cienkowski's original observation of the perforation of the cells of *Spirogyra* by this animal is, however, amply confirmed by the attacks I observed *V. lateritia* to make on the cells of *Mougeotia*, a plant which breaks at the junction of the cells much more readily than *Spirogyra*.

55. VAMPYRELLA PEDATA, *Klein*; *Blochmann, Die mikros. Thierwelt des Süsswass.*, I. *Protozoa, Hamburg*, 1895, p. 22.—Hyalodiscus rubicundus, *Hertwig & Lesser, in Archiv für mikr. Anat.* 1874, x. Suppl. p. 49, t. ii. f. 5. Plakopus ruber, *F. E. Schulze, in Archiv für mikr. Anat.* 1875, xi. p. 348, t. xix. ff. 9–16.

In the lakes at Capel Curig, and in Llyn-y-cwm-ffynon, N. Wales. Diameter of encysted stage 53–67 μ.

The animals observed were subspherical or ovoidal in form, with the endoplasm filled with small granules of a bright red colour. They had previously been gorging themselves with food, as they were filled with large numbers of small Desmids, the contents of which had also become of the same red colour. I was at first inclined to regard them as forms of *Hyalodiscus rubicundus*, but I think there is no doubt that the form described and figured by Hertwig & Lesser is merely a stage of *Vampyrella pedata*. The red colour of the Welsh examples was identical with the red colour observed in *Vampyrella lateritia*.

Class HELIOZOA.

Order APHROTHORACA.

Gen. ACTINOPHRYS, *Ehrenb.*

56. ACTINOPHRYS SOL, *Ehrenb. in Abhand. Akad. Wiss. Berlin*, 1830, pp. 42 etc. t. ii. f. 4; *Infus.* 1838, p. 303, t. xxxi. f. vi; *Wallich, in Ann. Mag. Nat. Hist.* 1863, xi. p. 446, t. x. f. 4; *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 235, t. xl.—Trichoda Sol, *Müller*. Actinophrys difformis, *Ehrenb.*

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General and abundant in still waters.

From Llyn Teyrn, N. Wales, several forms were noticed of a deep reddish-brown colour and which possessed rather fewer pseudopodia. It is quite possible they belonged to some other species of Rhizopod, but they were associated with normal forms of *A. Sol*. Diameter 26–27 μ.

Forma PICTA.—*Actinophrys picta*, Leidy, *l. c.* 1879, p. 241, t. xlvi. f. 4.

Near Brigg, Lincolnshire. Variable in size, the smallest forms having a diameter of only 31 μ. Leidy's species *A. picta* seems to me to be merely a form of *A. Sol* containing a considerable amount of more or less diffused chlorophyll granules. The general structure of the body, especially in the foamy appearance of the protoplasm and the nature of the pseudopodia, is in both cases identical.

57. ACTINOPHRYS SUBALPINA, sp. n. (Pl. **30**. fig. 36.)

Body subspherical, colourless, consisting of semitransparent, finely granulated protoplasm from which foamy vesicles are entirely absent. Nucleus single, large, finely granulated, generally prominent. Contractile vacuole single, prominently situated at one edge. Pseudopodia very long, straight, rigid, with a delicate central axis, twice or three times longer than the diameter of the body, very robust and gradually attenuated to a fine apex; containing numerous granules, but with perfectly smooth edges.

Diameter of body 42–61 μ; length of pseudopodia 60–125 μ.

Associated with *Pamphagus curvus* amongst wet moss on dripping rocks, Snowdon, N. Wales, at 3000 ft. elevation.

This fine Heliozoön appears to be quite distinct from any form of *Actinophrys Sol* I have yet come across. The *body*, which is relatively small, has a totally different structure from that of *A. Sol*, the finely granular protoplasm being absolutely devoid of the foam-like vesicles which are characteristic of the latter species. The *pseudopodia* are also of a different type, being relatively longer and stouter, and distinctly though gradually attenuated to a very fine point; they possess smooth edges, but contain numerous scattered groups of minute granules. Running up the middle of each pseudopodium is a delicate thread-like axis which can frequently be traced down into the body of the animal. The *nucleus*, which in *A. Sol* is usually difficult of observation, is in *A. subalpina* quite a prominent feature. It is subspherical, situated more or less in the centre of the body, and exhibits a delicately dotted appearance, probably due to numerous fine granules.

The *contractile vacuole* is relatively large and is situated at one side of the body. It commonly projects somewhat from the outer surface of the body, and but for this protuberance the animal presents an even edge all round.

The habitat of *A. subalpina* is somewhat remarkable, the animals occurring amongst mosses on the vertical face of dripping rocks, and also at a considerable elevation above sea-level. I have never yet found *A. Sol* except in still water.

The dumbbell-like form of the animal (which I figure to illustrate the species—Pl. **30.** fig. 36) might be considered merely as a case of fission, or as one stage in the conjugation of a pair of individuals. When found it was in the stage figured. It was watched for some hours, and it ultimately separated into two individuals; but, as these individuals were normal and did not undergo any further changes so long as they were under observation, I am inclined to regard it merely as ordinary fission.

Gen. ACTINOSPHÆRIUM, *Stein.*

58. ACTINOSPHÆRIUM EICHHORNII, *Stein, Sitzungsb. böhm. Akad. Wiss.* 1857, p. 41; *Hertwig & Lesser, in Archiv für mikr. Anat.* 1874, x. Suppl. p. 176, t. v. f. 1; *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 259, t. xli.—Actinophrys Eichhornii, *Ehrenb.* 1840.

Widely distributed in still water, but not so abundant as *Actinophrys Sol.*

Order CHLAMYDOPHORA.

Gen. HELIOPHRYS, *Greeff.*

59. HELIOPHRYS VARIANS, *nob.*—Heterophrys varians, *Schulze, in Archiv für mikr. Anat.* 1874, x. p. 386, t. xxvi. ff. 2–5. Heliophrys variabilis, *Greeff, ibid.* 1875, xi. p. 28, ff. 20–23.

In ditches, near Brigg, Lincolnshire. Diameter of body 25 μ.

There can be little doubt that *Heterophrys varians*, Schulze, and *Heliophrys variabilis* are forms of the same animal. The general body of the animal has in each case the same structure,

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and in each it is enveloped in a thick coat of apparently mucous material. This external envelope is very delicate, and in the specimens I observed was only rendered visible by small bacteria which adhered to its outer surface. The pseudopodia in the animals described by Schulze and Greeff are of the same type, and, moreover, this type is somewhat peculiar. Some, but not all, of the pseudopodia are branched, and to my mind this not only indicates a close affinity between the above-mentioned Heliozoa, but is quite sufficient to separate Greeff's *Heliophrys* from Archer's *Heterophrys*.

The specimens observed from Lincolnshire possessed one nucleus, and this was in a somewhat excentric position. No contractile vacuoles were observed, but I have no reason to believe that they were absent.

Gen. HETEROPHRYS, *Archer*.

60. HETEROPHRYS MYRIAPODA, *Archer, in Qu. Jour. Micr. Sci.* 1869, n. s. ix. p. 267, t. xvii. f. 4.

Llyn-y-cwm-ffynon, N. Wales. Diameter of body about 27 μ. The forms observed were somewhat small, but agreed in all respects with Archer's description and figure.

61. HETEROPHRYS RADIATA, sp. n. (Pl. 30. fig. 34.)

Body small, spherical, dark grey in colour, protoplasm densely filled with granules of variable size. Nucleus single, situated in an excentric position. No vacuoles observed. Outer coat of gelatinous material quite colourless, almost as thick as the diameter of the body, with a finely fimbriated outer surface. Pseudopodia numerous, long and delicate, with numerous scattered granules along their length.

Diameter of body 21 μ, with outer coat 53 μ; length of pseudopodia about 43 μ.

Epping Forest, Essex, in ponds.

This species of *Heterophrys* is nearest the one described by Hertwig and Lesser (in Archiv für mikr. Anat. 1874, x. Suppl. p. 215, t. v. f. 3) as *H. spinifera*; but it is distinguished from the latter by the larger body and the much less fimbriated outer covering. The pseudopodia are also much more numerous, and in proportion to the size of the body are considerably shorter.

From *H. myriapoda*, Archer, it is distinguished by its smaller size, its more copious outer coat, and by its longer and more slender pseudopodia.

This pretty little animal was obtained in washings of *Myriophyllum* from some large ponds in Epping Forest. None of the individuals observed possessed any green colour, and I was unable to detect the presence of any vacuoles. The outer zone which envelops the body is very wide, perfectly colourless, and its outer surface exhibits an exceedingly delicate fimbriation, much more delicate than the fringing of the corresponding structure in *H. spinifera* or *H. myriapoda*. The pseudopodia are delicate strands of protoplasm, with numbers of relatively large granules scattered at intervals along their length.

The extraordinary fimbriated (or 'spinous') outer coat of *H. Pavesii*, Garbini (in Zoolog. Anzeig. xxi. no. 575, 1898, p. 668, cum fig. 2), is alone a sufficient distinction between it and *H. radiata*.

Gen. SPHÆRASTRUM, *Greeff.*

62. **SPHÆRASTRUM FOCKEI**, *Archer, in Qu. Jour. Micr. Sci.* xvi. 1876, p. 858.—Heterophrys Fockei, *Archer, l. c.* ix. 1869, p. 267. Sphærastrum conglobatum, *Greeff, in Archiv für mikr. Anat.* 1875, xi. p. 29, t. ii. ff. 24-26.

Llyn Teyrn, N. Wales, among *Sphagnum cuspidatum*.

All the animals observed were solitary and some of them of small size, but otherwise they were exactly like Archer's description and figure.

Gen. LITHOCOLLA, *F. E. Schulze.*

63. **LITHOCOLLA GLOBOSA**, *F. E. Schulze, in Archiv für mikr. Anat.* 1874, x. p. 389, t. xxvi. ff. 6-10; *Schaudinn, 'Heliozoa' in Das Tierreich, Berlin,* 1896, p. 14.

Diameter of body 23 μ; length of pseudopodia about 31 μ.

Capel Curig, N. Wales.

The pseudopodia were granulated, and the investing sand-grains of the body-protoplasm were small and compact. I can see no difference between this animal and *Elæorhanis cincta*, Greeff (1873), except in the granulation of the pseudopodia. Perhaps the two are identical, and, if so, Greeff's name will take precedence. This Heliozoön was described originally from the Baltic Sea, and has also been recorded from freshwaters in Germany.

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Order CHALAROTHORACA.

Gen. POMPHOLYXOPHRYS, *Archer*.

64. POMPHOLYXOPHRYS PUNICEA, *Archer*, *in Qu. Jour. Micr. Sci.* ix. 1869, p. 386, t. xvi. f. 45; x. 1870, p. 105, t. xvi. f. 4.—Hyalolampe fenestrata, *Greeff, in Archiv für mikr. Anat.* 1869, v. p. 501, t. xxvi. f. 37; *Hertwig & Lesser, l. c.* 1874, x. Suppl. p. 221.

Wicken Fen, Cambridge; abundant among *Chara hispida* and *Utricularia vulgaris*, in peaty pools and ditches. Diameter of body about 44 μ. Pseudopodia few, radiating, and without granules. All the animals exhibited a rather quick gliding motion through the water. The body-protoplasm contained a peculiar red pigment and sometimes a small amount of chlorophyll, the latter perhaps obtained in the food. The globules of the enveloping skeleton were from 2–3·8 μ in diameter.

Hampsfell, Lancashire; scarce among *Myriophyllum* in pools. The examples were inactive and possessed few pseudopodia. Several large vacuoles were observed in one individual. The siliceous globules were 3·2–4 μ in diameter.

N. Wales:—Among *Sphagnum* in a pool near Llyn Teyrn, Snowdon; Moel Siabod; Capel Curig; Glyder Fach, abundant in pools at 2200 ft.

Gen. RHAPHIDIOPHRYS, *Archer*.

65. RHAPHIDIOPHRYS PALLIDA, *F. E. Schulze, in Archiv für mikr. Anat.* 1874, x. p. 377, t. xxvi. f. 1.

Small forms with zoochlorellids; diameter of body about 42 μ.

Llyn Idwal, N. Wales, among *Isoëtes*. (Pl. **30**. fig. 35.)

Although the forms noticed from N. Wales possess chlorophyll-bodies, I think they should be referred rather to *R. pallida*, Schulze, than to *R. viridis*, Archer. All the examples seen were solitary, and they possessed several contractile vacuoles, two characters which distinguish the former species from the latter. Moreover, the outer coat was colourless and the pseudopodia were ornamented with granules as in *R. pallida*. Schulze, in his description of *R. pallida*, mentions some larger, pale, shining corpuscles in the body-protoplasm, corresponding in size and position to the chlorophyll-bodies of *R. viridis*. The chlorophyll-bodies which I observed (zoochlorellids?) were numerous, but confined towards the periphery of the body. I think that the Welsh examples are best described as forms of *R. pallida*, Schulze, containing chlorophyll-bodies.

Gen. ACANTHOCYSTIS, *Carter*.

66. ACANTHOCYSTIS CHÆTOPHORA, *Leidy*, *Freshw. Rhiz. N. Amer.* 1879, p. 264, t. xliii. ff. 1–6.—Trichoda chætophora, *Schrank*, 1803. Actinophrys viridis, *Ehrenb.* 1833; *Infus.* 1838, p. 304, t. xxxi. f. vii. Acanthocystis turfacea, *Carter*, *in Ann. Mag. Nat. Hist.* 1864, xiii. p. 36, t. ii. f. 25; *Hertwig & Lesser*, *in Archiv für mikr. Anat.* 1874, x. Suppl. p. 204. A. viridis, *Greeff*, *in Archiv für mikr. Anat.* 1869, v. p. 481, t. xxvi. ff. 8–17. A. pallida, *Greeff*, *l. c.* p. 489, t. xxvii. f. 19.

A somewhat uncommon species, of which the two most interesting forms observed were the following:—

From Terrington, N. Yorkshire. A colourless form, with the smaller spines rather more numerous than the larger ones. Diameter of body 74 μ; length of large spines 40–44 μ; length of small spines 16–19 μ.

From Barnes Common, Surrey. A specimen containing numerous oval chlorophyll-bodies and with the outer protoplasmic envelope of a brown colour. Only the delicate spines were observed and these were much longer than usual. Diameter of body 67–76 μ; length of spines 38–54 μ.

67. ACANTHOCYSTIS PALUDOSA, sp. n. (Pl. **30**. figs. 32, 33.)

Body spherical, consisting of finely granular protoplasm, often colourless, but sometimes bright green from the presence of numerous chlorophyll corpuscles of variable size. Nucleus central or subcentral, rarely visible in the living animal. Outer surface of the body firm, sometimes of a pale yellow colour, beset with very numerous short siliceous spines. Spines delicate, simple, irregularly radiating, and with pin-head-like bases. Pseudopodia comparatively scanty, long and extremely delicate, beset along their length with numerous fine granules.

Diameter of body without spines 43–49 μ; length of spines 5·3–8 μ.

In ponds and ditches, Sheep's Green and Wicken Fen, Cambridgeshire. Near Shelf and near Ilkley, W. Yorkshire.

This animal is undoubtedly the same species as the

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"*Acanthocystis?*" mentioned and figured by Leidy in his Rhizopods of N. Amer. p. 270, t. xliii. ff. 14–16. It is of the same size, the delicate spines are exactly similar, and the individuals were colourless or filled with bright green chlorophyll corpuscles. I have obtained it from four separate localities, and on two occasions it was in quantity; and as it has also been observed from the United States, and the specimens I observed showed no appreciable variation, I think it quite worthy to be named as a distinct animal. The same Heliozoön is mentioned by Scourfield (P. Z. S. 1897, pp. 786–789) as occurring from Spitsbergen.

To a certain extent it resembles the four following species:—*Acanthocystis flava*, Greeff, *A. aculeata*, Hertwig & Lesser, *A. Pertyana*, Archer, and *A. spinifera*, Greeff. *A. paludosa* is sufficiently distinct to need no differentiation from the first two species. From *A. Pertyana* and *A. spinifera* it differs wholly in the nature of the spines, which are much more numerous and delicate. The pseudopodia are few in number and granular in appearance as in *A. spinifera*, but the outer surface of the body to which the spines are attached seems to be very much firmer. *A. paludosa* also resembles *A. erinaceus*, Penard, 1889 (*cfr.* Schaudinn, 'Heliozoa' in Das Tierreich, 1896, p. 19), but is a larger species with relatively shorter and more numerous spines.

In old and dead individuals the spines readily become disengaged from the firm outer coat, and then each spine is seen to be pin-shaped, with a capitate base or point of attachment.

The living animal protrudes a few long delicate pseudopodia which can withstand considerable irritation before being retracted. When the pseudopodia are fully out, the animal glides slowly through the water.

Order **DESMOTHORACA.**

Gen. CLATHRULINA, *Cienkowski.*

68. CLATHRULINA ELEGANS, *Cienk. in Archiv für mikr. Anat.* 1867, iii. p. 310, t. xviii.; *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 273, t. xliv.

Rare: among *Isoëtes* and numerous algæ, Llyn Ogwen, N. Wales. Pool near Windermere, Westmoreland. Also from the vicinity of Lough Neagh, Co. Armagh, Ireland; many of these specimens were attached in the encysted condition and had brown siliceous capsules.

EXPLANATION OF THE PLATES.

c.v. = contractile vacuole.
n. = nucleus.
v. = vacuole.

PLATE 28.

Fig. 1. *Cochliopodium longispinum*, sp. n. ×520. Active individual.
2. *Arcella artocrea*, Leidy. ×150. Empty shell.
3. *Gymnophrys cometa*, Cienkowski. ×520.
Figs. 4, 5. *Dactylosphærium radiosum*, Blochmann. ×520.
6–10. *Cochliopodium minutum*, sp. n. ×520. Active individuals.
11, 12. *Difflugia acuminata*, Ehrenb., var. *elegans*, nob. Fig. 11 is a specimen from Wicken Fen, Cambs., with living Diatoms attached to the outside of the shell; ×400. Fig. 12 is from Llyn-y-cwm-ffynon, N. Wales; ×520.
13, 14. *Difflugia pyriformis*, Perty. Very small forms. ×520.

PLATE 29.

Figs. 15, 16. *Centropyxis aculeata*, Stein. A form from Terrington, N. Yorks.; ×170. Fig. 16 is a portion of the shell-membrane; ×830.
17, 18. *Difflugia globulosa*, Dujardin. Very small forms. ×520.
19, 20. *Quadrula irregularis*, Archer. ×520.
21, 22. *Hyalosphenia cuneata*, Stein. ×520.
23–26. *Leptochlamys ampullacea*, gen. et sp. n. ×520.
Fig. 27. *Pamphagus curvus*, Leidy. ×520.
28. *Gromia stagnalis*, sp. n. ×520.
Figs. 29–31. *Vampyrella lateritia*, Leidy. ×520. Fig. 29, individual with pseudopodia fully extended. Fig. 30, an example just attacking a filament of *Mougeotia*. Fig. 31, a third example which has perforated a cell of *Mougeotia* and partially absorbed the cell-contents.

PLATE 30.

Figs. 32, 33. *Acanthocystis paludosa*, sp. n. ×520. Fig. 32, active individual of a bright green colour. Fig. 33 is a colourless individual with little protoplasm and a well-marked nucleus.
Fig. 34. *Heterophrys radiata*, sp. n. ×520.
35. *Rhaphidiophrys pallida*, F. E. Schulze. ×520. Individual containing chlorophyll-bodies.
36. *Actinophrys subalpina*, sp. n. ×520. Individual undergoing division, the nucleus having completely divided.

ISON AND SONS, Printers in Ordinary to His Majesty, St. Martin's Lane.

S,

G.S.West.

Linn Soc Journ Zool Vol XXVIII Pl 28

G.S.West del.
A.R.Hammond lith.

West, Newman imp.

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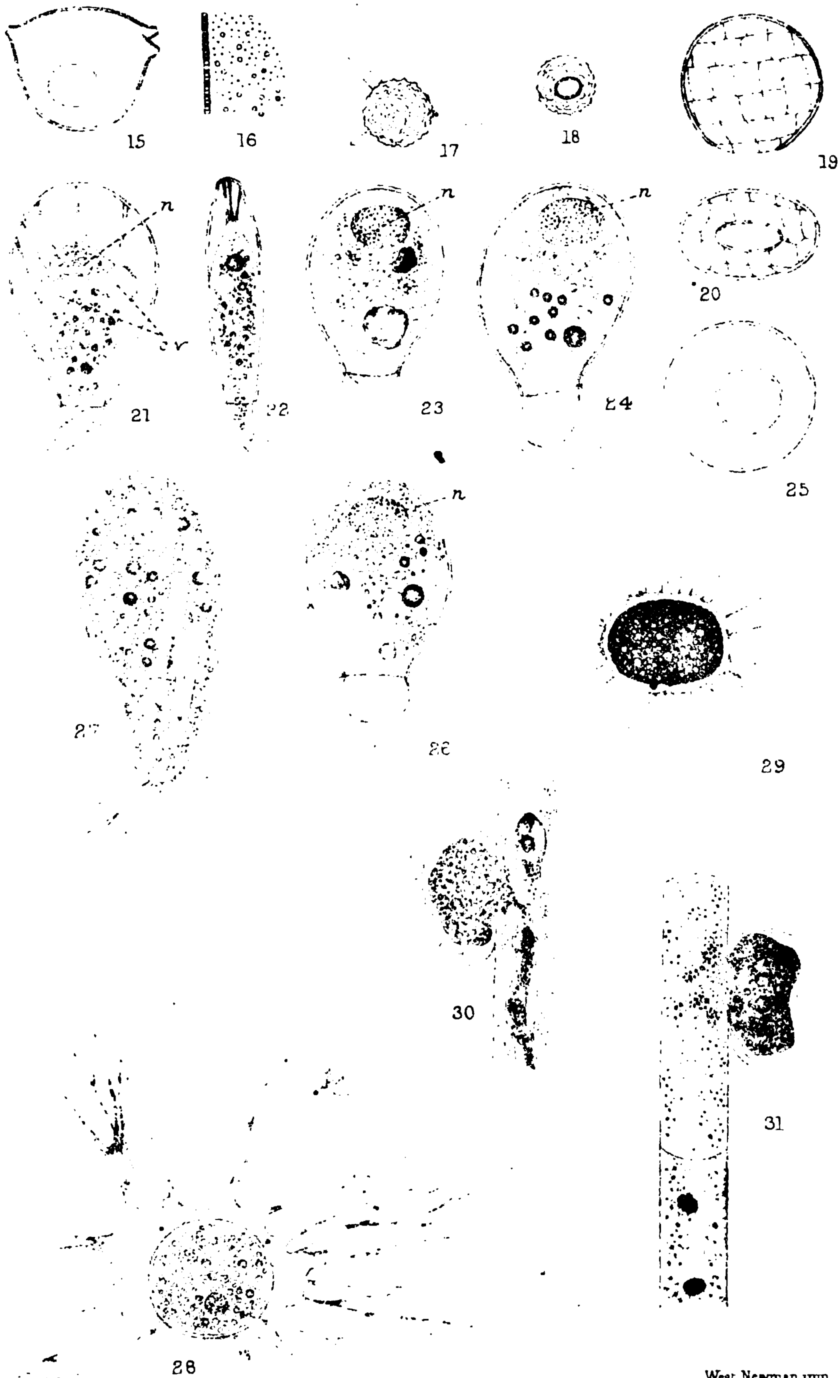

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BRITISH FRESHWATER RHIZOPODA

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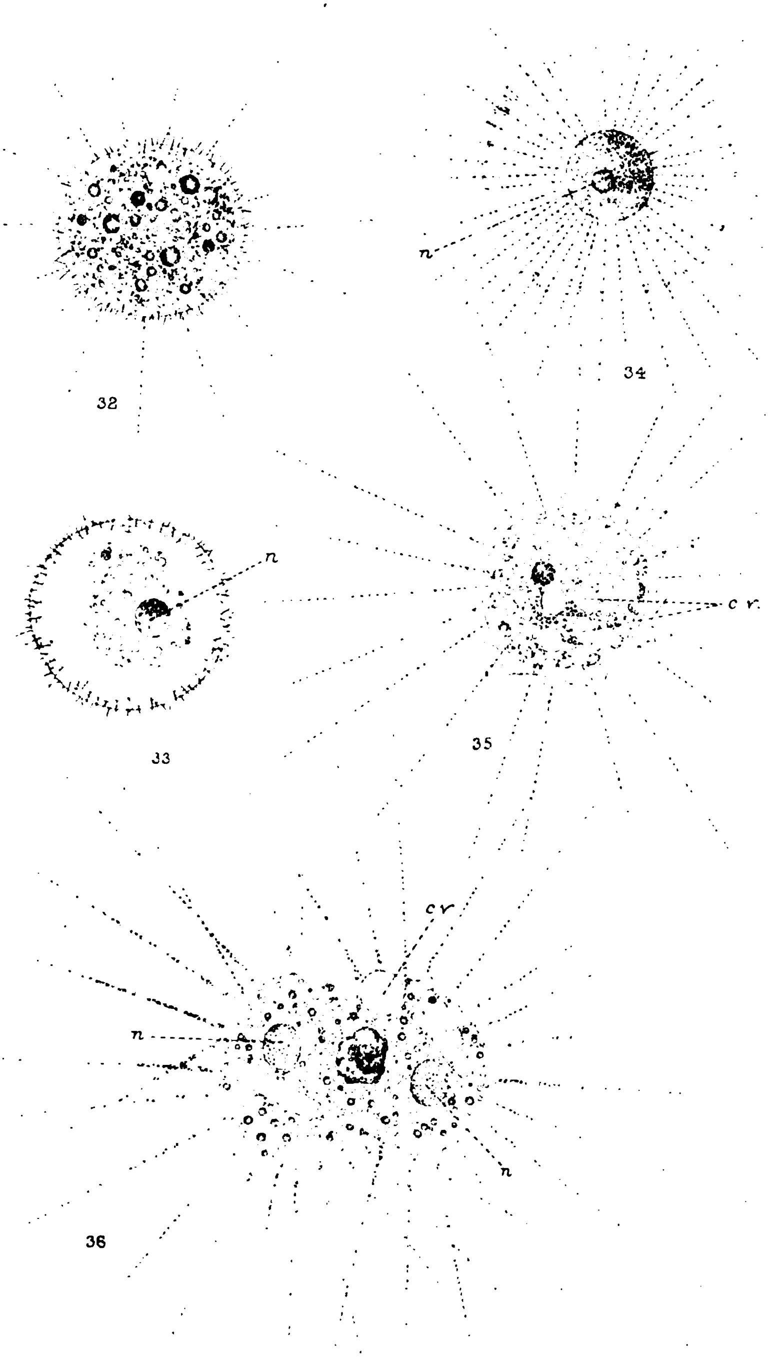

G.S.West del.
A.R.Hammond lith.

West, Newman imp.

BRITISH FRESHWATER RHIZOPODA.

Species of P

RISON AND SONS, Printers in Ordinary to His Majesty, St. Martin's Lane.

W + West G.S. S.

Periodicity of Phytoplankton of British Lakes.

⑨

Species of PERIDINIUM.

Extracted from the LINNEAN SOCIETY'S JOURNAL—BOTANY,
vol. xl. *May* 1912.

On the Periodicity of the Phytoplankton of some British Lakes.

By W. WEST, F.L.S., and G. S. WEST, M.A., D.Sc., F.L.S.

(PLATE 19 and 4 Text-figures.)

[Read 21st March, 1912.]

INTRODUCTORY REMARKS.

UP to the present little or nothing has been known of the periodicity of the British freshwater phytoplankton, a fact which, although rather deplorable in view of the extensive periodical plankton-investigations carried out in other countries during the past eight or ten years, may be attributed very largely to the comparative inaccessibility of the British lakes. For the most part, the lakes of the British Islands are situated at considerable distances from the great centres of population, and for the busy individual, with multifarious duties to perform, it is by no means easy to visit even a few selected lakes at frequent intervals throughout the year. Moreover, the expense incurred is very considerable.

By the aid of a grant from the Government Grant Committee of the Royal Society, and after much trouble, we succeeded in making the necessary arrangements for the regular monthly collection of plankton from several selected lakes. These were Ennerdale Water, Wastwater, and Windermere, in the English Lake District ; and Loch Lomond, Loch Katrine, Loch Lubnaig, and Loch Earn, in Scotland. Owing to unforeseen difficulties, however, the collections from Loch Earn could only be made for four months, and are therefore of small value, and those from Loch Lubnaig are likewise incomplete.

In all cases the collections were made from boats by means of the fine silken tow-nets we have previously described.

The first British record of the periodicity of phytoplankton is the account given by Fritsch [*] of the Thames river-plankton, in which he records the results of eight collections made from October 1902 to July 1903. Periodic collections of plankton were made in Loch Ness, Inverness, in 1904–05, and the results were published by Bachmann [†] in 1907. We have ourselves made brief reference to the periodicity of British river- and lake-plankton [‡], and have also published a complete account of the periodicity of the phytoplankton of Windermere [§]. These published results are discussed in their proper place, along with further investigations, and with the work done by investigators in other countries.

[*] F. E. Fritsch, in Ann. Bot. vol. xvii. (Sept. 1903).

[†] H. Bachmann, in Archiv für Hydrobiol. u. Planktonkunde, vol. iii. (1907).

[‡] W. & G. S. West, in Proc. Roy. Soc. B, vol. lxxxi. (1909).

[§] W. & G. S. West, in 'The Naturalist,' May–July 1909.

Most of our plankton-investigations have been of a qualitative character, as it was thought desirable that the pioneer work should be the acquirement of a sound general knowlege of the British freshwater phytoplankton, an exact knowledge of its constituents, and the points wherein the British phytoplankton differs so conspicuously from that of Central Europe and elsewhere. By a prolonged plankton-investigation of all the British lake-areas during the past ten years, we have acquired this knowledge very thoroughly. It is only since 1907 that we have been conducting observations of a more quantitative character in several of the more important and accessible lakes with a view to obtaining a knowledge of the periodicity of the plankton-organisms. The more detailed quantitative work concerning the phytoplankton, which, so far as we can see, in the British lake-areas will be quite of subordinate value, can be done piecemeal at any time by sufficiently qualified persons who possess the necessary means and time.

1. Ennerdale Water, Cumberland.

The most western of all the English Lakes, Ennerdale Water lies in a drainage-basin of its own, between mountains which rise on each side to 2000 feet. Its situation is somewhat desolate, and the valley above the lake is strewn with numerous moraines. The contamination of the water must be very slight, as only three houses are situated near its shores. It is two and a half miles in length by three-quarters of a mile broad, and has an average depth of 62 feet, the maximum depth being 148 feet. The collections were made regularly from August 1908 to July 1909, and the following monthly statement gives a brief outline of the changes in the plankton.

Aug. 1*st*, 1908. Temp. of water 60° F. (=15·5° C.). Mostly a Desmid-plankton, principally of small species, of which the most abundant were a biradiate form of *Staurastrum jaculiferum*, *Arthrodesmus crassus*, *Cosmarium subarctoum*, and *C. abbreviatum* var. *planctonicum*. Many other small species were more or less common, and abnormalities of most of the species, due to rapid divisions, were frequent. Two other Chlorophyceous algæ were of interest and were both fairly common. One was a rather small free-floating species of *Tetraspora* in which the pseudo-cilia were very distinct. This we have named *Tetraspora limnetica.* The other was a curious species of *Ankistrodesmus* which, although very minute, reminded one most forcibly of the partially untwisted threads in a yarn. This we have named *A. tortilis.* Of the Diatoms, *Rhizosolenia morsa* was the only abundant species. Other common constituents were *Chroococcus minutus* and *Peridinium inconspicuum. Ceratium Hirundinella* was not so frequent as one would have expected. Rotifers were fairly common, especially *Notholca longispina.*

Sept. 4*th*, 1908. Temp. of water 59° F. (=15° C.). This collection was a Desmid-plankton with an abundance of *Ceratium Hirundinella.* As in the previous month, the smaller species of Desmids, and especially the spiny ones, were abundant. *Spondylosium planum* was also very common, occurring in short filaments of from 3 to 22 cells. *Rhizosolenia morsa* was still common, and *Lyngbya limnetica* and *Chroococcus minimus* had greatly increased in amount. Rotifers fairly common, and a few Copepods.

Oct. 13*th*, 1908. Temp. of water 50° F. (=10° C.). Not much different from preceding month. A Desmid-plankton of small species, with a considerable quantity of *Ceratium Hirundinella*. *Rhizosolenia morsa* and *Lyngbya limnetica* both common. Rotifers fairly common.

Nov. 2*nd*, 1908. Temp. of water 47° F. (=8·3° C.). Small Desmids still common, but *Ceratium Hirundinella* greatly diminished in numbers. *Rhizosolenia morsa* at its maximum abundance, and *Lyngbya limnetica* still fairly common. Few Rotifers.

Dec. 11*th*, 1908. Temp. of water 46° F. (=7·7° C.). The small Desmids less numerous, the reduction in the numbers of *Arthrodesmus crassus* being especially noticeable. *Rhizosolenia morsa* still very common, but *Lyngbya limnetica* much reduced in amount. No Peridinieæ were observed. Rotifers fairly numerous.

Jan. 8*th*, 1909. Temp. of water 38° F. (=3·3° C.). Great reduction in the numbers of Desmids, although *Spondylosium planum*, *Arthrodesmus crassus*, *A. triangularis* var. *subtriangularis*, and *Staurastrum jaculiferum* (f. *biradiata*) are still evident. Much detritus present. *Rhizosolenia morsa* reduced in numbers, but *Lyngbya limnetica* much as in December. First appearance of *Peridinium Willei*. Rotifers rather rare.

Feb. 6*th*, 1909. Temp. of water 42° F. (=5·5° C.). The collection contained comparatively little phytoplankton. Some of the small spiny Desmids were not uncommon, and *Spondylosium planum* was not infrequent. Diatoms were few in numbers and Rotifers rare. The great bulk of the plankton consisted of Copepods.

March 3*rd*, 1909. Temp. of water 39° F. (=4° C.). There was a notable increase in the phytoplankton. The spiny Desmids again common, and *Arthrodesmus crassus* has reappeared. *Spondylosium planum* once more common. *Dictyosphærium pulchellum* and the young stages of *Sphærocystis Schroeteri* both very frequent. A noteworthy feature was the reappearance in quantity of *Rhizosolenia morsa* with rather shorter spines. Rotifers few, but Nauplii very numerous.

April 3*rd*, 1909. Temp. of water 42° F. (=5·5° C.). A poor plankton collection. The phytoplankton consisted mostly of a very even mixture of a few species, amongst which the spiny Desmids were the most conspicuous. Very few Rotifers or Copepods.

May 3*rd*, 1909. Temp. of water 50° F. (=10° C.). Smaller species of Desmids very numerous again, and owing to the relatively rapid divisions many abnormalities were noticed among the spiny species. *Sphærocystis Schroeteri* was common. Copepods and Nauplii both abundant.

TABLE OF PHYTOPLANKTON FROM ENNERDALE WATER.

In this Table the relative frequency of a species is indicated thus:—very rare, "rrr"; rare, "rr"; infrequent, "r"; fairly common, "c"; common, "cc"; abundant, "ccc."

SPECIES.	1908.					1909.						
	August. 15·5° C. (=60° F.).	September. 15° C. (=59° F.).	October. 10° C. (=50° F.).	November. 8·3° C. (=47° F.).	December. 7·7° C. (=46° F.).	January. 3·3° C. (=38° F.).	February. 5·5° C. (=42° F.).	March. 4° C. (=39° F.).	April. 5·5° C. (=42° F.).	May. 10° C. (=50° F.).	June. 13·3° C. (56° F.).	July. 17° C. (=62° F.).
Chlorophyceæ.												
Œdogonium sp. (sterile)	...	...	rrr	...	...	...	...	rrr	rrr	rrr		
Ulothrix zonata, (Web. & Mohr) Kütz.	...	...	...	...	...	...	...	...	...	r		
Myxonema subsecundum, (Kütz.) Hazen	...	...	...	...	...	...	...	...	rr			
Gonatozygon monotænium, De Bary	...	...	...	...	rr	...	...	...	...	rr	rr	
" *Brébissonii*, De Bary	...	rrr	...	...	...	...	...	...	rrr			
" *Kinahani*, (Arch.) Rabenh.	...	...	...	...	...	...	...	...	...	...	...	rrr
Genicularia elegans, W. & G. S. West	rrr	rrr	rrr	...	rrr	r	rr	...	...	...	...	rrr
Cylindrocystis diplospora, Lund., var. *major*, West	...	...	...	...	...	...	...	...	...	rr	rr	
Euastrum verrucosum, Ehrenb., var. *reductum*, Nordst.	...	...	...	...	...	...	...	...	...	rr	r	
Micrasterias Sol, (Ehrenb.) Kütz.	rrr											
Cosmarium abbreviatum, Racib., var. *planctonicum*, W. & G. S. West	ccc	cc	c	c	rr	rrr	...	rr	rrr	rrr	rr	c
" *bioculatum*, Bréb.	rr	rr	...	...	...	...	...	r	...	r	r	
" *connatum*, Bréb.	...	...	...	...	...	...	...	...	...	rrr	rr	
" *contractum*, Kirchn., var. *ellipsoideum*, (Elfv.) W. & G. S. West	...	...	...	...	...	...	rrr					
" *depressum*, (Näg.) Lund.	...	rrr	...	...	...	...	...	...	...	rrr		
" *subarctoum*, (Lagerh.) Racib.	ccc	c	r	r	rrr	...	...	...	rr	r	c	cc
" *subcrenatum*, Hantzsch	...	...	...	rrr	rrr							
Xanthidium antilopæum, (Bréb.) Kütz.	rr	r	...	...	...	...	...	rrr	...	rrr	rrr	rr
" " var. *depauperatum*, W. & G. S. West	...	rr	rr	...	rrr	rr	rrr	rrr	rrr	r	r	r
Arthrodesmus crassus, W. & G. S. West	ccc	ccc	cc	c	rrr	rrr	...	rr	rr	c	c	cc
" *Incus*, (Bréb.) Hass.	...	...	...	...	...	...	...	...	...	rrr		
" *triangularis*, Lagerh., var. *subtriangularis*, (Borge) W. & G. S. West	cc	c	r	rr	rr	r	r	r	r	r	c	cc
Staurastrum anatinum, Cooke & Wills	rrr	...	rrr									

Staurastrum Arctiscon, (Ehrenb.) Lund.	rrr	...	...	...	...	...	...	...	...	...	rrr	rrr
,, *aculeatum*, (Ehrenb.) Menegh.	...	...	...	...	...	...	...	...	...	rrr		
,, *curvatum*, West	rr	...	rrr	...	rrr	...	...	rr	...	rr		
,, *cuspidatum*, Bréb., var. ***maximum*****, West**	...	rrr	rr									
,, *dejectum*, Bréb.	rrr	rrr	...	...	...	rrr	...	...	...	rrr	rr	
,, *denticulatum*, (Näg.) **Arch.**	rr	r	rr	rr	rr	...	...	rr	...	...	r	
,, *furcigerum*, Bréb.	...	...	...	rrr								
,, *jaculiferum*, West, **forma *biradiata***	ccc	cc	cc	c	c	r	r	c	c	c	cc	cc
,, *longispinum*, (Bail.) **Arch.**	...	...	...	...	...	rrr	...	...	...	rrr		
,, *lunatum*, Ralfs, var. ***planctonicum*****, W. & G. S. West**	c	rr	...	rr	...	rrr	...	...	rr	r	c	rr
,, *megacanthum*, Lund., var. *scoticum*, W. & **G. S. West**	rrr	rrr	...	rrr								
,, *paradoxum*, Meyen, var. *longipes*, Nordst.	...	...	...	rrr	...	...	...	...	rrr			
,, *sexangulare*, (Buln.) Rabenh.	...	...	...	...	rrr							
,, *vestitum*, Ralfs	rrr	rrr	rrr									
Sphærozosma vertebratum, Ralfs, **var. *punctulatum*, W. & G. S. West**	...	...	rrr									
Spondylosium planum, W. & G. S. West	rr	cc	c	c	c	r	r	c	...	...	...	rrr
Hyalotheca dissiliens**, (Sm.) Bréb.**	rrr	rrr	...	...	...	...	...	...	...	rr	rrr	
,, ***mucosa*****, (Dillw.) Ehrenb.**	...	...	...	...	rrr	...	...	...	...	rr		
Oocystis parva**, W. & G. S. West**	r	rr	rrr									
,, *lacustris*, Chodat	...	...	...	rrr	rrr							
Ankistrodesmus falcatus, (Corda) Ralfs	rrr	...	...	rrr	rrr	rrr	...	rrr	...	...	...	rrr
,, ,, var. ***spirilliformis*****, G. S. West**	...	...	rrr									
,, *tortilis*, sp. n.	r	...	...	...	...	...	...	...	...	rr	rr	rr
Dictyosphærium pulchellum, Wood	c	c	r	r	rrr	...	rrr	c	r	r	...	r
Botryococcus Braunii, Kütz.	...	...	...	...	...	...	...	...	...	rrr	rrr	rrr
Sphærocystis Schroeteri, Chodat	...	rrr	rrr	rr	r	rr	...	r	r	cc	ccc	r
Tetraspora limnetica**, W. & G. S.** West	c	...	...	...	...	...	...	...	...	...	...	rr
Glæocystis gigas**, (Kütz.) Lagerh.**	r	...	rrr	...	...	...	rrr	rrr				
Heterokontæ.												
Askenasyella conferta**, W. & G. S. West**	cc	cc	c	c	rr							
Bacillarieæ.												
Cyclotella compta**, Kütz.**	rr	rrr	rrr	...	...	...	rr	rr	r	r	c	rr
Rhizosolenia morsa**, W. & G. S. West.**	c	c	cc	cc	c	r	rr	r	r	...	...	r
Tabellaria fenestrata**, (Lyngb.) Kütz.**	rr	rr	rr	rrr	rrr	rrr	rrr	rr	rr	r	r	r
,, ,, var. *asterionelloides*, **Grun.**	...	...	...	...	...	...	...	...	...	...	rr	
,, *flocculosa*, (Roth) Kütz.	...	rrr	rr	...	rr	rr	...	rrr	rr	rr	rr	rr
Synedra Acus, (Kütz.) Grun.	...	...	rrr	...	rrr	rrr	...	...	...	...	...	rrr
,, *radians*, (Kütz.) Grun.	...	...	...	...	...	...	...	rrr	r	rr		
,, *Ulna*, (Nitzsch) Ehrenb.	...	...	...	rrr	rr	rrr	...	...	rrr	rrr	r	rrr
Asterionella formosa, Hass.	...	...	...	...	...	...	...	...	...	rrr		
Eunotia biceps, (W. Sm.) G. S. West	...	...	rrr									
,, ***Diadema*****, Ehrenb.**	...	...	...	...	...	...	...	rrr				
,, ***major*****, (W. Sm.) Rabenh.**	...	...	...	...	rrr	...	...	...	rrr	rrr	rr	
,, ***pectinalis*****, (Kütz.) Rabenh.**	...	...	rr	...	...	...	...	...	...	rr	r	

PHYTOPLANKTON FROM ENNERDALE WATER (*continued*).

SPECIES.	1908.					1909.						
	August. 15·5° C. (=60° F.).	September. 15° C. (=59° F.).	October. 10° C. (=50° F.).	November. 8·3° C. (=47° F.).	December. 7·7° C. (=46° F.).	January. 3·3° C. (=38° F.).	February. 5·5° C. (=42° F.).	March. 4° C. (=39° F.).	April. 5·5° C. (=42° F.).	May. 10° C. (=50° F.).	June. 13·3° C. (=56° F.).	July. 17° C. (=62° F.).
Bacillarieæ (*cont.*).												
Achnanthes microcephala, Kütz.	rrr	rr	rrr	rrr	...	...	...	...	...	...	...	rr
Gomphonema intricatum, Kütz.	rr	rrr	rrr	rrr	rrr	rrr	rrr	rrr	rrr	...	...	rrr
Navicula alpina, (W. Sm.) Ralfs	...	...	...	...	rrr	...	...	...	...	...	rr	
" *divergens*, Ralfs	...	...	rrr	...	rrr	...	...	...	rrr			
" *major*, Kütz.	...	...	...	...	rrr	...	...	rrr				
Vanheurckia rhomboides, Bréb., var. *saxonica*, G. S. West	r	rr	rr	rrr	rrr	rrr	rrr	rrr	...	...	rrr	rrr
Cocconema cymbiforme, Ehrenb., var. *parvum*, (W. Sm.) V. Heurck	...	...	...	...	...	rrr	...	rrr	rrr			
Nitzschia Sigma, (Kütz.) W. Sm.	...	...	...	...	rrr	...	...	rrr	rrr	...	...	rrr
Surirella biseriata, Bréb.	...	...	...	...	rr	rr	...	rrr	...	rrr	rr	
" *linearis*, W. Sm.	...	...	...	...	rrr	...	...	rrr	...	rrr	rrr	
" *ovalis*, Bréb., var. *angusta*, (Kütz.) V. Heurck	...	...	...	rrr	...	...	...	rrr				
" *robusta*, Ehrenb.	...	...	...	...	...	...	...	...	...	...	r	c
" " var. *splendida*, (Ehrenb.) V. Heurck	...	rrr	...	...	rr	...	rrr	...	rr	rrr	r	c
Myxophyceæ.												
Plectonema Boryanum, Gomont	...	...	rrr	...	...	rrr	rrr	rrr	rrr			
Lyngbya limnetica, Lemm.	rr	r	c	r	r	rr	...	rrr				
Oscillatoria Agardhii, Gomont	...	...	...	...	...	rrr	...	...	...	...	...	rrr
Merismopedia glauca, (Ehrenb.) Näg.	...	rrr										
Aphanocapsa delicatissima, W. & G. S. West	rrr	...	...	rrr								
Aphanothece microscopica, Näg.	...	...	...	...	rrr							
Gomphosphæria lacustris, Chodat	...	...	...	...	...	rr	...	...	rrr	...	rrr	
Chroococcus minutus, (Kütz.) Näg.	cc	r	...	...	...	...	...	rrr				
" *minimus*, (v. Keissler) Lemm.	r	c	rr	r								
Flagellata.												
Dinobryon cylindricum, Imhof	...	...	...	...	...	...	...	...	rrr	rr		
" *crenulatum*, W. & G. S. West	rrr	...	...	...	...	...	...	...	...	rrr		
" *elongatum*, Imhof	rr											
" *sociale*, Ehrenb.	rr											
Synura uvella, Ehrenb.	rr	rrr										
Peridinieæ.												
Ceratium Hirundinella, O. F. Müller	rr	co	co	rr	...	...	...	...	...	r	c	
Peridinium inconspicuum, Lemm.												

June 1st, 1909. Temp. of water 56° F. (=13·3° C.). Considerable increase in the number of Desmids. *St. lunatum* var. *planctonicum* abundant, and many of the rarer species becoming frequent. *Sphærocystis Schroeteri* in great quantity, and *Peridinium Willei* quite common. No *Rhizosolenia* was observed either in this month or in May. Very few Rotifers, but many Copepods and Nauplii, and much detritus.

July 2nd, 1909. Temp. of water 62° F. (=17° C.). Largely a Desmid-plankton with Peridinieæ. Also much detritus. The small spiny Desmids and *Cosmarium subarctoum* very numerous. Rotifers fairly common. *Rhizosolenia morsa* reappeared in moderate quantity.

In Ennerdale Water the dominant constituents of the phytoplankton are Chlorophyceæ, more especially Desmids. Neither the Diatoms nor the Myxophyceæ are at any time conspicuous, although quantities of the delicate *Rhizosolenia morsa* occur at certain times. The total number of species observed from August 1908 to July 1909 was 91, of which 49 (or 53 per cent.) were Chlorophyceæ, 24 (or 26 per cent.) Bacillarieæ, 9 (or 9·9 per cent.) Myxophyceæ, 5 (or 5·5 per cent.) Flagellata, and 3 (or 3·3 per cent.) Peridinieæ.

If the foregoing table be compared with the list of phytoplankton found in this lake in May 1903 *, it will be seen that some 16 species which occurred at that time were entirely absent in the period from August 1908 to July 1909. All these constituents were, however, of the more casual type.

The plankton of Ennerdale Water has two very indistinct phases :—

I. *December–May* (cold period, with vernal rise of temperature). Mixed plankton ; Diatoms more or less frequent but none dominant ; Desmids in comparatively small numbers.

II. *June–November* (warm period, with autumnal decline of temperature). Desmid-plankton, with a few of the Protococcales, few Diatoms, and *Lyngbya limnetica*.

The dominant Desmids attain their maximum abundance in August, and maintaining their numbers through the autumnal fall in temperature, begin to visibly thin out in December. Of the few Protococcales which occur, *Dictyosphærium pulchellum*, *Askenasyella conferta*, and *Tetraspora limnetica* also reach their greatest abundance in August and September, whereas *Sphærocystis Schroeteri* is most numerous in June.

There is apparently no maximum of Diatoms in this lake, and with one exception almost all the recorded species are scarce. Particularly noticeable is the great scarcity of *Asterionella* and the star-dispositions of *Tabellaria*, and *Melosira* is completely absent. *Rhizosolenia morsa* is the only Diatom which was observed to become abundant, attaining its greatest maximum in October and November (temp. 10° and 8·3° C. respectively) near the close of the autumnal decline in temperature, with a second slight increase in March and April. A similar periodicity was exhibited by this species in Wastwater.

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* *Vide* W. & G. S. West, in 'The Naturalist,' April 1909.

Fig. 1.

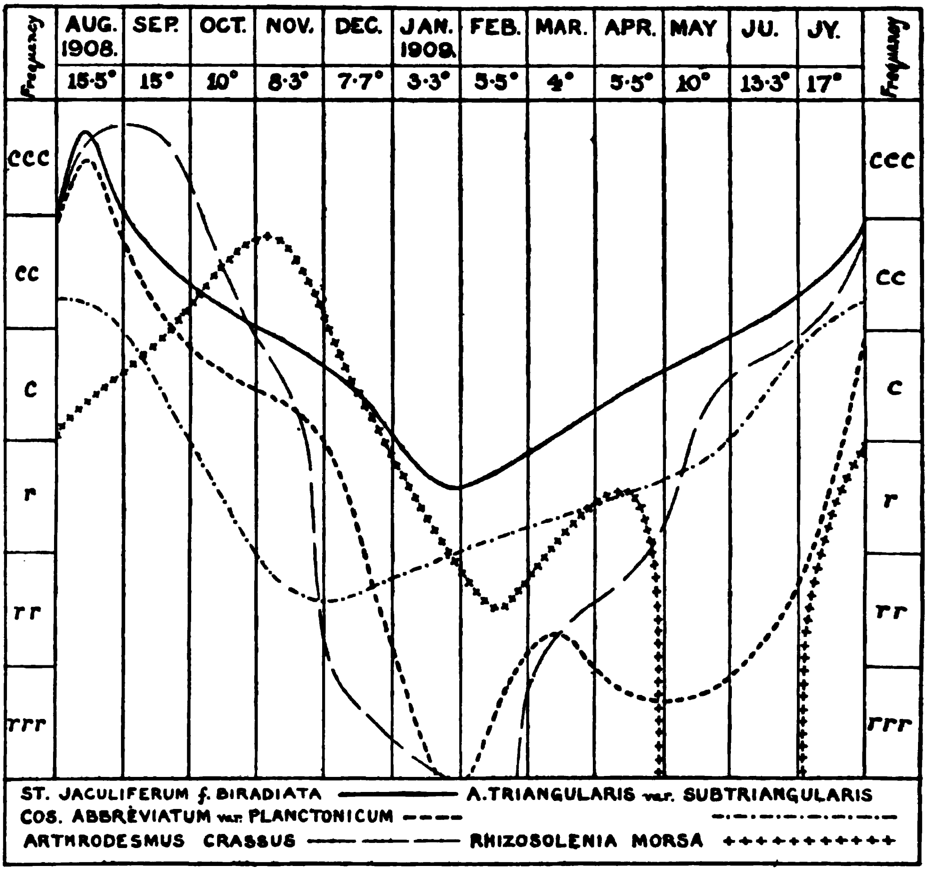

Chart of the periodicity of five of the most abundant constituents of the phytoplankton of Ennerdale Water. The temperatures are in degrees Centigrade.

Flagellates and Myxophyceæ are rare in Ennerdale Water, although there is a small maximum of *Lyngbya limnetica* in October.

Peridinium Willei only occurs from January to July, reaching its maximum in the latter month and then disappearing from the plankton. In

Windermere this organism attained its maximum in August, but persisted in very small numbers from September to December.

Ceratium Hirundinella had two maxima—a small one from June to July, and a more pronounced one from September to October.

2. Wastwater, Cumberland.

This is the deepest of the English lakes, having an average depth of 135 feet and a maximum depth of 258 feet. It is about three miles in length by about half a mile in breadth, and is 204 feet above sea-level. The drainage is received from the western side of Scafell (3162 feet) and Scafell Pike (3210 feet), and from the southern slopes of the Steeple, the Pillar, and Kirk Fell. The lake contains a large volume of water, and is practically free from all contamination. The collections were made at approximately monthly intervals from August 1908 to July 1909.

Aug. 4th, 1908. Temp. of water 63° F. (=17·2° C.). The dominant constituent of the phytoplankton was *Staurastrum jaculiferum*. A few other Desmids were present, but on the whole the amount of phytoplankton was rather small. *Peridinium Willei* was common. Rotifers were numerous and Copepods abundant.

Sept. 5th, 1908. Temp. of water 51° F. (=10·5° C.). Plankton not unlike that of previous month, with *Staurastrum jaculiferum* dominant. *Rhizosolenia morsa* and *Sphærocystis Schroeteri* both common. Rotifers numerous. Copepods abundant.

Oct. 5th, 1908. Temp. of water 60° F. (=15·5° C.). Phytoplankton not unlike that of September, with some abundance of *Staurastrum jaculiferum*. One of the most noteworthy Desmids was *Genicularia elegans*. *Sphærocystis Schroeteri* and *Rhizosolenia morsa* were both exceedingly abundant. Rotifers very abundant. Copepods few.

Nov. 4th, 1908. Temp. of water 54° F. (=12·2° C.). Phytoplankton very similar to that of October, with the same dominant species. *Genicularia elegans* also occurred again. Rotifers very abundant.

Dec. 3rd, 1908. Temp. of water 48° F. (=8·9° C.). Great reduction in quantity of *Sphærocystis Schroeteri* and slight diminution in *Staurastrum jaculiferum*, but considerable increase in *Rhizosolenia morsa*, which attains its maximum abundance in this month. Rotifers abundant. Few Entomostraca.

Jan. 4th, 1909. Temp. of water 46° F. (=7·8° C.). The numbers of *Staurastrum jaculiferum* further reduced, and also a considerable falling off in *Rhizosolenia morsa*. *Peridinium Willei* had become frequent. Large Copepods were the dominant feature of the plankton.

Feb. 5th, 1909. Temp. of water 42° F. (5·5° C.). *Staurastrum jaculiferum* still further reduced in numbers. Diatoms more numerous, especially

TABLE OF PHYTOPLANKTON FROM WASTWATER.

The relative frequency is indicated as before.

SPECIES.	1908.					1909.						
	August. 63° F. (=17·2° C.).	September. 51° F. (=10·5° C.).	October. 60° F. (=15·5° C.).	November. 54° F. (=12·2° C.).	December. 48° F. (=8·9° C.).	January. 46° F. (=7·8° C.).	February. 42° F. (=5·5° C.).	March. 41° F. (=5° C.).	April. 40° F. (=4·4° C.).	May. 46° F. (=7·8° C.).	June. 54° F. (=12·2° C.).	July. 51° F. (=10·6° C.).
Chlorophyceæ.												
Œdogonium spp. (sterile)	rr	...	...	rrr	...	rrr	...	...	rr	...	rr	
Microspora amœna, (Kütz.) Rabenh.	...	...	...	...	...	...	...	...	...	...	rr	
Mougeotia spp. (sterile)	...	rrr	rrr	rrr	rrr	...	...	...	rrr	rrr	rr	
Genicularia elegans, W. & G. S. West	...	...	rr	rrr	...	...	...	...	...	rrr		
Pleurotænium Ehrenbergii, (Ralfs) De Bary	...	...	...	...	...	...	...	...	...	...	rrr	
Cosmarium Botrytis, (Bory) Menegh.	...	...	...	...	..	...	...	...	...	...	rrr	
„ *depressum*, (Näg.) Lund., var. *achondrum*, (Boldt) W. & G. S. West.	...	...	rr	...	rrr	...	...	...	...	...	rr	
„ *punctulatum*, Bréb	...	...	...	...	rrr							
Xanthidium antilopæum, (Bréb.) Kütz.	...	rrr										
Staurastrum curvatum, West	...	...	rrr	...	...	...	...	...	...	rrr	rrr	rrr
„ *cuspidatum*, Bréb., var. *maximum*, West	...	rrr	rr	rrr	rrr	rrr	...	...	...	rrr	rr	
„ *denticulatum*, (Näg.) Arch.	r	rr	...	...	rr	...	...	...	...	r	rr	r
„ *furcigerum*, Bréb.	rr	rrr	...	...	...	...	...	...	...	...	...	r
„ *jaculiferum*, West (f. *triradiata*)	ccc	ccc	ccc	ccc	cc	c	r	r	r	c	ccc	ccc
„ *lunatum*, Ralfs, var. *planctonicum*, W. & G. S. West	...	...	...	...	...	...	...	...	...	...	rr	
„ *paradoxum*, Meyen	rr	...	...	...	...	...	...	...	rrr			
Sphærozosma vertebratum, Ralfs, var. *punctulatum*, W. & G. S. West	...	rrr	...	...	...	...	...	...	...	...	rr	
Hyalotheca dissiliens, (Sm.) Bréb.	...	...	...	...	...	...	...	...	...	...	rr	
„ *mucosa*, Ehrenb.	...	...	rrr	...	...	rrr	...	...	...	...	...	rrr
Ankistrodesmus falcatus, (Corda) Ralfs, var. *acicularis*, (A. Br.) G. S. West	...	rr	...	...	...	...	...	...	...	rrr		
Elakatothrix gelatinosa, Wille	...	...	rrr	rrr	rrr	rrr	...	...	rrr	r	c	cc
Oocystis parva, W. & G. S. West	...	...	rrr	...	...	...	...	...	...	...	r	
„ *lacustris*, Chodat	...	rrr	r	rr	rrr	rrr	...	...	rrr	r	c	c
Glæocystis gigas, (Kütz.) Lagerh., var. *maxima*, West	...	...	...	...	...	...	...	rrr	rrr	rr	c	r
Sphærocystis Schroeteri, Chodat	c	cc	ccc	ccc	r	rr	...	...	rrr	r	c	c

Bacillarieæ.												
Melosira granulata, Ralfs	...	...	...	rrr	...	...	...	...	rrr			
Rhizosolenia morsa, W. & G. S. West	...	c	cc	cc	ccc	c	rr	rrr	...	r		
Tabellaria flocculosa, (Roth) Kütz.	...	rr	rr	...	rrr	...	...	rrr	...	...	r	rrr
„ *fenestrata*, (Lyngb.) Kütz.	rr	rr	rr	rr	...	rr	r	rr	...	rr		
Fragilaria capucina, Desmaz.	...	rrr	...	...	...	...	...	...	...	rr	rr	
Synedra Acus, (Kütz.) Grun.	...	...	...	...	...	...	rr	rr	...	...	rr	
„ *pulchella*, Kütz.	...	...	...	rrr	rrr							
Ceratoneis Arcus, (Ehrenb.) Kütz., var. *Amphioxys* (Rabenh.) De Toni	...	...	...	...	...	rrr	rr	rr				
Eunotia lunaris, (Ehrenb.) Grun.	...	rrr	...	...	...	...	...	...	...	..	rr	
„ *gracilis*, (Ehrenb.) Rabenh.	...	...	..	...	...	rrr	rr	rr	...	...	rrr	
„ *biceps*, (W. Sm.)	...	...	...	...	rrr							
Epithemia turgida, (Ehrenb.) Kütz.	...	...	...	...	...	...	rrr					
Gomphonema geminatum, Ag.	...	...	...	...	...	...	...	...	...	...	rrr	
„ *intricatum*, Kütz.	...	...	...	rrr	...	rrr	rr	rr	...	rr	r	
„ „ var. *Vibrio*, (Ehrenb.) Van Heurck	. .	...	...	...	...	...	...	...	...	rrr		
Vanheurckia rhomboides, (Ehrenb.) Bréb., var. *saxonica*, (Rabenh.) G. S. West	...	...	...	...	...	...	...	...	...	rr	r	rr
Cocconema gracile, (Rabenh.) G. S. West	...	...	...	...	...	...	...	...	...	...	rrr	
„ *cymbiforme*, Ehrenb., var. *parvum*, (W. Sm.) Van Heurck	...	...	...	...	...	...	rrr	...	...	...	rr	
Surirella biseriata, Bréb.	...	...	...	...	...	...	rr					
„ *ovalis*, Bréb., var. *angusta*, (Kütz.) Van Heurck	...	...	...	...	...	...	...	...	...	rrr	...	rr
„ *robusta*, Ehrenb., var. *splendida*, (Ehrenb.) Van Heurck	...	rrr	...	rrr	rrr	...	...	...	...	rr	rr	
Phæophyceæ.												
Stichoglœa olivacea, Chodat	..	...	...	...	...	c						
Myxophyceæ.												
Merismopedia glauca, (Ehrenb.) Näg.	...	...	...	...	...	...	...	...	...	...	...	rrr
Aphanocapsa delicatissima, sp. n.	...	...	...	...	...	r						
Flagellata.												
Dinobryon cylindricum, Imhof, var. *divergens*, (Imhof) Lemm.	...	...	...	...	...	...	...	...	...	...	rr	
Peridinieæ.												
Peridinium Willei, Huitf.-Kaas	c	rr	rr	rr	r	r	rr	rrr	rrr	rr	c	cc

Tabellaria fenestrata and *Surirella biseriata*. Much fine detritus was present. Rotifers few.

March 5th, 1909. Temp. of water 41° F. (=5° C.). *Staurastrum jaculiferum* uncommon. Various Diatoms present, but no single species at all dominant. Much fine detritus and vegetable hairs. Rotifers and Entomostraca practically absent.

April 6th, 1909. Temp. of water 40° F. (=4·4° C.). *Staurastrum jaculiferum* rather more frequent. Individuals of various groups of the Protococcales beginning to appear. Diatoms practically absent. Much coarse detritus. Few Rotifers and a few Nauplii.

Fig. 2.

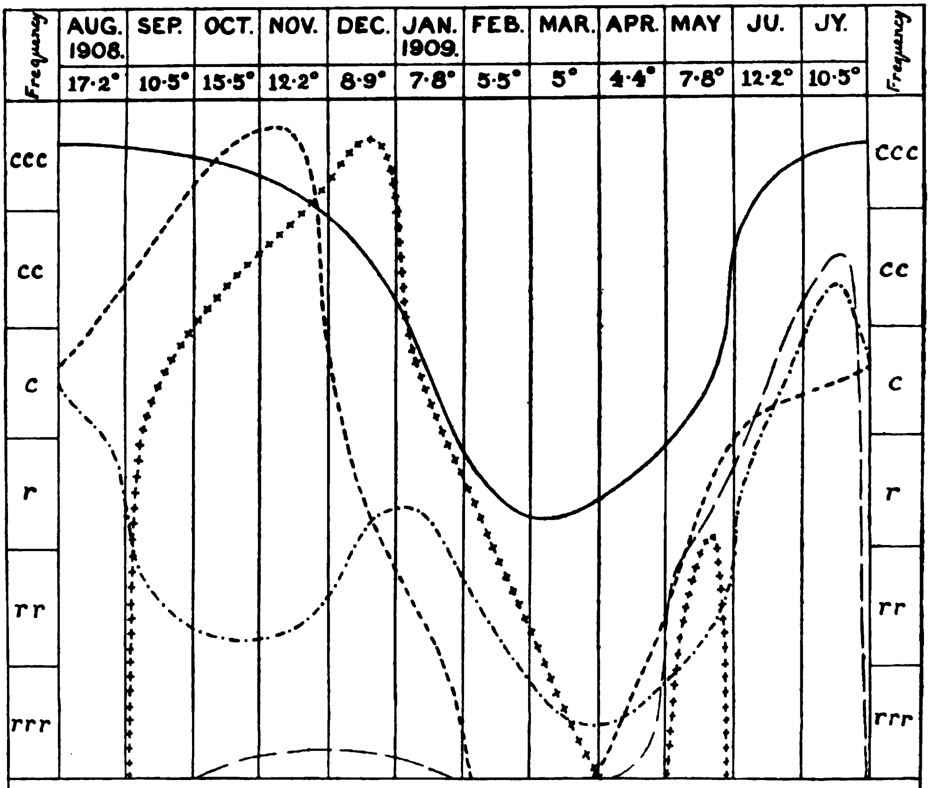

Chart of the periodicity of five of the most conspicuous constituents of the phytoplankton of Wastwater. The temperatures are in degrees Centigrade.

May 3rd, 1909. Temp. of water 46° F. (=7·8° C.). *Staurastrum jaculi-*

ferum now quite common. Other members of the Chlorophyceæ and also Diatoms increasing in numbers. Rotifers fairly common.

June 4th, 1909. Temp. of water 54° F. (=12·2° C.). The Chlorophyceæ have now attained their maximum abundance, both as regards number of species and number of individuals. *Peridinium Willei* common. Rotifers numerous.

July 5th, 1909. Temp. of water 51° F. (=10·5 C.). *Staurastrum jaculiferum* very abundant. *Elakatothrix gelatinosa* very common and at its maximum. *Peridinium Willei* common. Rotifers abundant.

In Wastwater the chief constituents of phytoplankton are Chlorophyceæ and Diatoms, although *Peridinium Willei* is a conspicuous summer constituent. The total number of species observed from August 1908 to July 1909 was 50, of which 25 (or 50 per cent.) were Chlorophyceæ, 20 (or 40 per cent.) Bacillarieæ, 1 (or 2 per cent.) Phæophyceæ, 2 (or 4 per cent.) Myxophyceæ, 1 (or 2 per cent.) Flagellata, and 1 (or 2 per cent.) Peridinieæ.

Of these constituents only seven became really common, and only four of these were at any time abundant. Thus the actual bulk of phytoplankton is rather small. All the species recorded from the plankton of this lake in September 1906 * were observed in the twelve months under consideration.

The plankton of Wastwater has two fairly distinct phases :—

I. *January–May* (cold period, with vernal rise of temperature) Chlorophyceæ at their minimum ; Diatoms frequent but none dominant.

II. *June–December* (warm period, with autumnal decline of temperature). Chlorophyceæ at their maximum, dominated by great abundance of *Staurastrum jaculiferum*. General maximum of Diatoms in June, although marked by abundance of Chlorophyceæ. *Rhizosolenia morsa* attaining a great maximum in December.

Although 20 species of the Bacillarieæ occur in the plankton of Wastwater, only one of them, *Rhizosolenia morsa*, ever becomes very abundant. This delicate Diatom appears rather suddenly in September and at once gets very numerous, attaining a great maximum in December. It then rapidly declines and disappears in March, appearing again in small quantity in May. It thus reaches its great maximum during the autumn fall in temperature. *Melosira granulata* was one of the rarest constituents of the plankton, and *Asterionella* and the star-dispositions of *Tabellaria* were entirely absent.

Of the Chlorophyceæ, the one outstanding constituent was *Staurastrum jaculiferum*, which occurred in enormous abundance, without any diminution, from June to November. The individuals were very finely developed, with long spines, and even throughout the winter months were not at all infrequent. *Oocystis lacustris* and *Glœocystis gigas* were fairly common in June, and *Sphærocystis Schroeteri* reached a considerable maximum from October to November. The most interesting of all the green constituents, however, was *Elakatothrix gelatinosa*, one of the Protococcales only previously observed by Wille in the lakes of Norway*. So far as we have ascertained, this Alga is not only absent from all the other lakes of the English Lake District, but has not been observed in any other lake in the British Islands. It occurred sparingly during the autumnal fall of temperature, but was abundant in June and July during the vernal rise in temperature.

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* *Vide* W. & G. S. West, in 'The Naturalist,' April 1909.

Peridinium Willei attained its maximum in July, as in Ennerdale Water, but during the period of investigation it was never absent from the plankton and a second smaller maximum occurred from December to January.

On the whole, the phytoplankton of Wastwater is by no means rich. A very minute species of *Aphanocapsa* was present in the January collections, which we have described as a new species—*A. delicatissima*.

3. WINDERMERE, WESTMORELAND.

The phytoplankton of this body of water, the largest of the English Lakes, has been worked out in detail for a period of 12 months from September 1907 to August 1908 †. It has been shown to have three fairly distinct phases.

I. *January–April* (cold period). *Melosira granulata* phase. During February and March the phytoplankton is at its minimum.

II. *May–July* (vernal rise in temperature). First maximum of *Asterionella gracillima* in May and June.

III. *August–December* (autumnal fall in temperature). The Desmid-phase extends from August to November, and is most noticeable in September and October. In November is a second maximum of *Asterionella gracillima*.

One of the leading features in the periodicity is the double maximum of *Asterionella gracillima*. There is a vernal maximum in May and June, and an equally great autumnal maximum from November to January, both occurring at approximately the same water-temperature (7°–8° C.). *Melosira granulata* attained its maximum in April with a water-temperature of 1·7° C.).

4. LOCH LOMOND, DUMBARTONSHIRE.

This lake is of considerable size, being 21 miles in length and 5 miles in width at its widest part. Although situated between mountains rising to 2000 feet on one side and 3000 feet on the other, it is only 23 feet above sea-level. The lake-basin consists of outcrops of metamorphic and Devonian rocks. The collections were made to the north-west of Luss at monthly intervals from September 1908 to August 1909.

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* N. Wille, in Biol. Centralbl. xviii. 1898, p. 2.

† W. & G. S. West, in 'The Naturalist,' 1909, pp. 188–193, 260–266, text-figs. 3 & 4, and pl. 7.

Sept. 2nd, 1908. Temp. of water 59° F. (=15° C.). A mixed plankton consisting of Chlorophyceæ and Bacillarieæ, with a considerable quantity of *Cœlosphærium Kützingianum*. Among the Chlorophyceæ certain species of *Staurastrum*, such as *St. paradoxum* var. *cingulum*, *St. lunatum* var. *planctonicum*, and others, stood out conspicuously, and *Tetraspora lacustris* and *Ankistrodesmus falcatus* are quite common. The only common Diatoms are *Tabellaria fenestrata* and *T. flocculosa*. Rotifers abundant, but few Copepods.

Oct. 2nd, 1908. Temp. of water 60° F. (=15·5° C.). Very similar to the collections of the preceding month, but with less *Ceratium Hirundinella*, *Cœlosphærium Kützingianum* in great quantity.

Nov. 2nd, 1908. Temp. of water 54° F. (=12·2° C.). Diminution in Chlorophyceæ, more especially in number of Desmids. *Cœlosphærium* still very abundant, but the colonies beginning to dissociate. *Asterionella* and *Tabellaria* fairly common. Copepods numerous.

Dec. 1st, 1908. Temp. of water 49° F. (=9·4° C.). Chlorophyceæ much reduced, although varieties of *Staurastrum paradoxum* are still common. There is a great influx of detritus and a rapid diminution of *Cœlosphærium*. The amount of *Melosira granulata* much increased. Copepods and *Bosmina* fairly common.

Jan. 9th, 1909. Temp. of water 44° F. (=6·6° C.). All the phytoplankton greatly reduced, except the varieties of *Staurastrum paradoxum* and *Melosira granulata*. Few Rotifers, Nauplii, and *Bosmina*.

Feb. 4th, 1909. Temp. of water 43° F. (=6·1° C.). The plankton contains much detritus. Desmids scarcer than in January, but varieties of *Staurastrum paradoxum* not rare. *Melosira granulata* and *Surirella robusta* var. *splendida* both increasing in quantity. Few Rotifers and many Nauplii.

March 2nd, 1909. Temp. 40° F. (=4·4° C.). Less detritus and more phytoplankton in the collections. *Cœlosphærium Kützingianum* increasing in quantity. *Asterionella formosa* common and *Melosira granulata* about as abundant as in February. Desmids present in increased numbers and showing signs of active division. Rotifers few, but plenty of Nauplii and Entomostraca, especially large specimens of *Bosmina*.

April 3rd, 1909. Temp. of water 41° F. (=5° C.). Very great increase in Diatoms, more especially *Melosira granulata* and *Asterionella*. The genera *Eunotia*, *Navicula*, *Surirella*, and *Cyclotella* well represented. Desmids frequent, but obscured by abundance of Diatoms. *Cœlosphærium Kützingianum* common.

May 3rd, 1909. Temp. of water 45° F. (=7·2° C.). Diatoms entirely dominant, more particularly *Melosira granulata*. *Asterionella* not quite so

TABLE OF PHYTOPLANKTON FROM LOCH LOMOND.

The relative frequency is indicated as before.

SPECIES.	1908.				1909.							
	September. 59° F. (=15° C.).	October. 60° F. (=15·5° C.).	November. 54° F. (=12·2° C.).	December. 49° F. (=9·4° C.).	January. 44° F. (=6·6° C.).	February. 43° F. (=6·1° C.).	March. 40° F. (=4·4° C.).	April. 41° F. (=5° C.).	May. 45° F. (=7·2° C.).	June. 56° F. (13·3° C.).	July. 60° F. (=15·5° C.).	August. 59° F. (=15° C.).
Chlorophyceæ.												
Œdogonium sp. (sterile)	r	...	...	...	...	rr	r	...	...	rr	rr	r
Mougeotia sp. (sterile)	...	...	...	...	...	...	...	...	...	rrr	...	r
Zygnema sp. (sterile)	...	...	r	...	...	...	...	...	...	...	rr	r
Gonatozygon monotænium, De Bary	...	...	...	...	...	...	...	...	...	...	...	rr
Closterium Kützingii, Bréb.	rr	rr	rr	rrr	...	rr	r	...	...	rr	r	rr
,, *macilentum*, Bréb.	...	...	...	...	rrr	...	rrr	...	rr			
Cosmarium contractum, Kirchn., var. *ellipsoideum*, (Elfv.) W. & G. S. West	rr	rr	rr	...	...	...	...	...	rrr	rr	r	
Xanthidium antilopæum, (Bréb.) Kütz., var. *depauperatum*, W. & G. S. West	...	rr	...	...	..	...	...	rr	...	...	rrr	
,, *subhastiferum*, West, var. *Murrayi*, W. & G. S. West, forma *triquetra*	r	rr	...	...	rrr	rr	rr	rr	rr	rr	r	r
Arthrodesmus triangularis, Lagerh., var *subtriangularis*, (Borge) W. & G. S. West	c	r	rrr	...	rrr	rrr	rrr	rrr	r	r	r	r
Staurastrum lunatum, Ralfs, var. *planctonicum*, W. & G. S. West	c	r	rr	rr	rrr	rrr	rrr	rrr	rrr	rr	r	c
,, *megacanthum*, Lund., var. *scoticum*, W. & G. S. West	r	rr	rr	rr	rrr	rrr	rr	rrr	rrr	rr	rr	r
,, *paradoxum*, Meyen, var. *longipes*, Nordst.	c	r	r	c	r	rr	r	r	rr	r	r	c
,, ,, var. *cingulum*, W. & G. S. West	cc	c	r	r	r	r	r	r	r	c	c	c
Spondylosium planum, nob.	r	rr	rrr	...	...	...	...	rrr	rr	rr	r	c
Hyalotheca mucosa, Ehrenb.	...	...	...	...	...	...	...	...	...	...	...	rr
Scenedesmus bijugatus, (Turp.) Kütz.	rrr											
Ankistrodesmus falcatus, (Corda) Ralfs	c	c	r	...	...	...	rrr	...	rr	rr	r	c
,, ,, *acicularis*, (A. Br.) G. S. West	rrr	rr	...	...	...	...	rrr					
Closteriopsis longissima, Lemm., var. *tropicum*, W. & G. S. West	...	...	...	...	...	rrr						
Oocystis lacustris, Chodat	r	rr	...	...	...	...	...	...	...	r		
Nephrocytium lunatum, West	rrr	...	...	...	...	...	...	...	...	rrr	rr	

Dictyosphærium pulchellum, Wood	...	...	...	...	r							
Botryococcus Braunii, Kütz.	r	r	r	...	...	...	...	...	...	rr	rr	rr
Sphærocystis Schroeteri, Chodat	c	c	rr	rr	rrr	...	rrr	rrr	rr	rr	c	c
Tetraspora lacustris, Lemm.	c	c	r	...	...	...	...	...	r	c	c	c
Glœocystis gigas, (Kütz.) Lagerh.	r	rrr	...	...	...	...	...	...	rr			
Bacillarieæ.												
Melosira granulata, (Ehrenb.) Ralfs	rrr	rr	r	c	c	cc	cc	ccc	ccc	ccc		
Cyclotella compta, Kütz.	c	c	r	rr	rr	rrr	rrr	rr	r	c	r	r
Tabellaria fenestrata, (Lyngb.) Kütz.	c	r	r	rr	rr	rr	rrr	rrr	rr	r	cc	c
„ „ var. *asterionelloides*, Grun.	c	c	r	rr	rr	rr	rrr	rrr	rrr	c	cc	cc
„ *flocculosa*, (Roth) Kütz.	r	r	rrr	...	...	rrr	rrr	rr	rr	rr	rr	r
Fragilaria capucina, Desmaz.	...	...	...	...	...	...	...	...	rr	r		
Synedra pulchella, Kütz.	...	...	rrr	...	...	...	rrr	rr	r	r	rr	rr
„ *radians*, (Kütz.) Grun.	r	...	...	...	...	rrr	rrr	rr	r	c	rr	
Asterionella formosa, Hass.	c	c	r	r	r	r	c	cc	cc	c	r	r
„ *gracillima*, Heib.	c	c	c	c	r	rr	r	c	cc	ccc	ccc	ccc
Eunotia gracilis, (Ehrenb.) Rabenh.	...	...	...	...	rr	...	rrr	r				
Gomphonema intricatum, Kütz.	...	...	...	...	rrr	...	rrr	rrr				
Navicula radiosa, Kütz.	...	...	...	...	...	...	...	rr				
Surirella biseriata, Bréb.	...	...	...	..	...	...	...	rr	...	...	...	r
„ *robusta*, Ehrenb.	...	...	...	...	...	...	...	rr				
„ „ var. *splendida*, (Ehrenb.) V. Heurck	rrr	rrr	rrr	rr	r	r	c	c	r	rrr	rrr	rrr
Myxophyceæ.												
Oscillatoria Agardhii, Gomont	rr	rr	...	...	...	rrr	...	...	...	rrr	rrr	rrr
Cœlosphærium Kützingianum, Näg.	ccc	ccc	ccc	r	r	c	cc	cc	cc	cc	cc	ccc
Gomphosphæria aponina, Kütz.	...	...	...	...	r	...	...	...	r			
„ *lacustris*, Chodat	...	...	...	...	...	...	...	...	...	rrr		
Aphanocapsa delicatissima, sp. n.	rr											
Aphanothece nidulans, Richter, var. *endophytica*, var. n.	cc	cc	cc	...	...	...	cc	cc	cc	c	cc	cc
Microcystis elabens, (Bréb.) Kütz.	...	rr	rrr									
„ *Flos-aquæ*, (Wittr.) Kirchn.	...	...	...	...	...	...	...	...	...	...	...	rrr
Flagellata.												
Dinobryon cylindricum, Imhof, var. *divergens*, (Imhof) Lemm.	c											
„ „ var. *Schauinslandii*, Lemm.	c	r	rr	rrr								
Peridinieæ.												
Ceratium Hirundinella, O. F. Müller	c	r	...	...	...	...	...	...	...	rr	rr	r
Peridinium Willei, Huitf.-Kaas	c	r	...	...	...	...	...	...	rrr	rr	r	r

conspicuous. *Cœlosphærium* very common. Desmids not uncommon, but somewhat masked by abundance of Diatoms. Rotifers very few. Nauplii very rare.

June 2nd, 1909. Temp. of water 56° F. (=13·3° C.). Diatoms still dominant, but the *Melosira*-plankton has given place to a mixed plankton in which *Tabellaria* and *Cyclotella* are common. Increase in the Chlorophyceæ, including particularly fine specimens of *Tetraspora lacustris*. Both 3-horned and 4-horned forms of *Ceratium Hirundinella* present. Rotifers few. Entomostraca few.

Fig. 3.

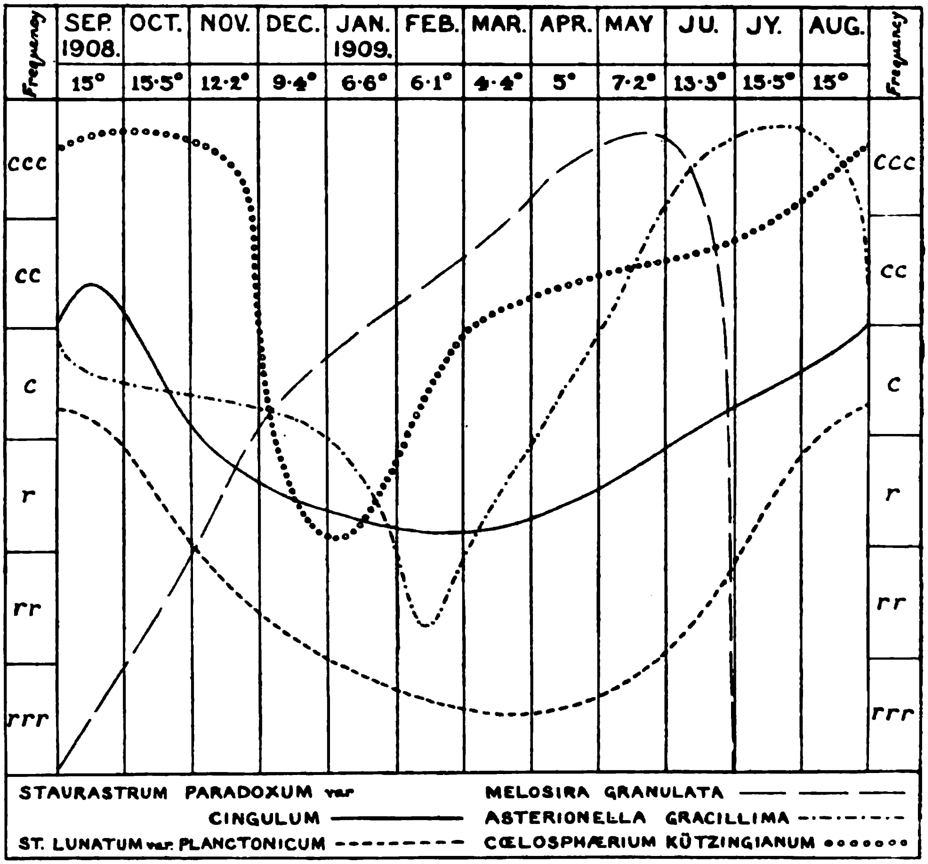

Chart of the periodicity of five of the dominant constituents of the phyloplankton of Loch Lomond. The temperatures are in degrees Centigrade.

July 3rd, 1909. Temp. of water 60° F. (=15·5° C.). Mixed plankton in which Desmids are much more numerous. Complete disappearance of *Melosira granulata* and diminution of *Asterionella*. Increase in amount of

Tabellaria fenestrata, most of the colonies being transitional to the var. *asterionelloides*. *Cœlosphærium* increasingly abundant, and *Peridinium Willei* in slightly increased amount. Rotifers numerous. Entomostraca few.

Aug. 2nd, 1909. Temp. of water 59° F. (=15° C.). Mixed plankton in which *Cœlosphærium Kützingianum* is the dominant constituent. Desmids more conspicuous, and *Sphærocystis Schroeteri* fairly common. Diatoms numerous, mostly *Tabellaria* and *Asterionella*. Rotifers fairly common. Entomostraca rare.

Loch Lomond has a mixed plankton of Chlorophyceæ and Diatoms, in which quantities of *Cœlosphærium Kützingianum* occur nearly all the year round. The total number of species observed from September 1908 to August 1909 was 50, of which 25 (or 50 per cent.) were Chlorophyceæ, 14 (or 28 per cent.) Bacillarieæ, 8 (or 16 per cent.) Myxophyceæ, 1 (or 2 per cent.) Flagellata, and 2 (or 4 per cent.) Peridinieæ.

There are two more or less distinct phases in the phytoplankton of Loch Lomond :—

I. *December–June* (cold period, with vernal rise of temperature). Chlorophyceæ at their minimum ; Diatoms rapidly increasing in numbers towards the latter end of the period, and culminating in a great maximum of *Melosira granulata* and *Asterionella gracillima*.

II. *July–November* (warm period with autumnal decline of temperature). Chlorophyceæ attain their maximum, along with a great maximum of *Cœlosphærium* and a considerable abundance of certain Diatoms, such as *Tabellaria*.

Of the fourteen species of Bacillarieæ observed in the plankton, seven become more or less common at some period of the year. Two of these, *Asterionella gracillima* and *Melosira granulata*, become dominant: the former from June to August, when it is associated with quantities of *Tabellaria fenestrata* ; and the latter in June, when it occurs in such prodigious quantity that the lake may be described as possessing a *Melosira*-plankton. In both April and May, among the thousands of straight filaments of *Melosira* were a few coiled ones such as those recorded by Ostenfeld * from a lake in Iceland. The two species of *Tabellaria* are most abundant in the summer months, but *Surirella robusta* var. *splendida* attained its maximum in March and April.

Of the Chlorophyceæ, several Desmids were common in July, August, and September, and a few fairly abundant up to November or December. *Ankistrodesmus falcatus* was also common in the autumn. Both *Sphærocystis Schroeteri* and *Tetraspora lacustris* were in considerable abundance from

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* C. H. Ostenfeld, in Botanisk Tidsskrift, xxvi. (1904) p. 233, f. 5 (p. 232).

July to October, specimens of the latter being particularly good. The occurrence of these members of the Tetrasporaceæ simultaneously in about equal abundance does not lend support to the view suggested by one of the authors as a result of the examination of Australian material *, viz., that these two plankton-algæ are states of one and the same organism. Rather does it confirm Wesenberg-Lund's observations † that the two are probably distinct.

The Blue-green Alga *Cœlosphærium Kützingianum* is one of the leading constituents of the plankton of Loch Lomond, dominating the whole plankton from August to September. It is never absent at any time of the year, although it is greatly reduced in the cold period when *Melosira granulata* is so abundant. An interesting discovery was the occurrence of an endophytic *Aphanothece* within the mature colonies of the *Cœlosphærium*. On careful scrutiny this *Aphanothece* has been found in other lakes. (Consult p. 432.) The Flagellates and Peridinieæ are only common in the month of September.

5. Loch Katrine, Perthshire.

This well-known Scottish loch is 8 miles in length by three-quarters of a mile in breadth, and is 364 feet above sea-level. Its greatest depth is 495 feet. Towards the eastern end, where the collections were made, the surrounding mountains rise to 2393 feet. The collections were made monthly from August 1908 to July 1909.

Aug. 18*th*, 1908. Temp. of water 60° F. (=15·5° C.). Varieties of *Staurastrum paradoxum* and *St. cuspidatum* var. *maximum* were very common. *Cœlosphærium Kützingianum* very abundant. Diatoms few and scarce. Rotifers frequent. *Bosmina* very abundant.

Sept. 17*th*, 1908. Temp. of water 56° F. (=13·3° C.). Very similar in all respects to the August plankton, but containing rather more detritus and fragmentary organic matter.

Oct. 16*th*, 1908. Temp. of water 55° F. (=12·7° C.). Several species of *Staurastrum* still pretty common. *Cœlosphærium* much reduced in numbers. *Merismopedia tenuissima* common. *Rhizosolenia morsa* makes its appearance. Great increase in amount of fine detritus. No Rotifers and very few Nauplii.

Nov. 17*th*, 1908. Temp. of water 50° F. (=10° C.). *Staurastra* still numerous. Very little *Cœlosphærium* and with colonies in poor condition. Filaments of *Œdogonium* very common and much finely divided organic matter. *Rhizosolenia morsa* more numerous. No Rotifers or Entomostraca present.

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* G. S. West, in Journ. Linn. Soc., Bot. xxxix. (1909) pp. 75, 76.

† C. Wesenberg-Lund, "Studier over de Danske Söers Plankton," Dansk. Ferskv.-Biol. op. 5, Kjöbenhavn, 1904, p. 21 (of Summary).

Dec. 15*th*, 1908. Temp. of water 45° F. (=7·2° C.). *Staurastra* still numerous. Very little *Cœlosphærium*, but a great increase in amount of organic detritus. Sterile *Œdogonium* still common. *Rhizosolenia morsa* fairly frequent, and other Diatoms becoming evident. First appearance of the coiled *Lyngbya contorta*.

Jan. 18*th*, 1909. Temp. of water 43° F. (=6·1° C.). *Staurastrum paradoxum* still fairly common. *Cœlosphærium* distinctly rare and colonies in very poor condition. Much fine detritus and few Diatoms. *Lyngbya contorta* not uncommon. Entomostraca and Nauplii very rare.

Feb. 16*th*, 1909. Temp. of water 40° F. (=4·4° C.). Very similar to the January plankton, but with a larger quantity of *Lyngbya contorta*.

March 16*th*, 1909. Temp. of water 39° F. (=3·9° C.). *Staurastra* becoming more numerous, and also considerable increase in *Cosmarium abbreviatum* var. *planctonicum*. All the Desmids showing active vegetative division. Diatoms uncommon. Much detritus; few Rotifers; and no Entomostraca.

April 18*th*, 1909. Temp. of water 46° F. (=7·7° C.). Desmids numerous, especially *Staurastrum*. *Cœlosphærium* decidedly increased, and Diatoms not uncommon. Rotifers rare; few Nauplii.

May 18*th*, 1909. Temp. of water 46° F. (=7·7° C.). Desmids numerous, especially the typical form of *Staurastrum paradoxum*. No increase in quantity of *Cœlosphærium*. Diatoms moderately abundant. *Lyngbya contorta* entirely disappeared. Rotifers few; Nauplii very numerous.

June 17*th*, 1909. Temp. of water 54° F. (=12·2° C.). Great increase in number of Desmids, so that the plankton has now become a Desmid-plankton, largely composed of a few species of the genus *Staurastrum*. The Chlorophyceæ have reached their maximum, and the Diatoms, although numerous, are not conspicuous. *Rhizosolenia morsa* is again common, and the frustules are considerably wider than in the preceding November and December. Few Rotifers; Nauplii and Crustacea practically absent.

July 16*th*, 1909. Temp. of water 60° F. (=15·5° C.). Plankton rather similar to that of preceding month. Still a Desmid-plankton, but various Chlorophyceæ and *Peridinium Willei* much more numerous, so that the Desmids do not dominate to the extent that they did in June. *Rhizosolenia morsa* abundant, and also a considerable increase in the quantity of *Cœlosphærium Kützingianum*. Few Rotifers. *Bosmina longirostris* not uncommon.

Loch Katrine has a mixed plankton of Chlorophyceæ, Diatoms, and Myxophyceæ. The total number of species observed from August 1908 to July 1909 was 63, of which 35 (or 55·5 per cent.) were Chlorophyceæ, 16 (or 25·6 per cent.) Bacillarieæ, 1 (or 1·5 per cent.) Phæophyceæ, 8 (or 12·8 per cent.) Myxophyceæ, 1 (or 1·5 per cent.) Flagellata, and 2 (or 3·1 per per cent.) Peridinieæ.

TABLE OF PHYTOPLANKTON FROM LOCH KATRINE.

The relative frequency is indicated as before.

SPECIES.	1908. August. 60° F. (=15·5° C.).	September. 56° F. (=13·3° C.).	October. 55° F. (=12·7° C.).	November. 50° F. (=10° C.).	December. 45° F. (=7·2° C.).	1909. January. 43° F. (=6·1° C.).	February. 40° F. (=4·4° C.).	March. 39° F. (=3·9° C.).	April. 46° F. (=7·7° C.).	May. 46° F. (=7·7° C.).	June. 54° F. (=12·2° C.).	July. 60° F. (=15·5° C.).
Chlorophyceæ.												
Œdogonium sp. (sterile)	c	c	rr	c	c	rrr	...	r	rr	rr	r	r
Ulothrix subtilis, Kütz., var. *variabilis*. (Kütz.) Kirchn.	...	...	rr	...	...	rr	rr	rrr	rrr	...	rrr	
Mougeotia sp. (sterile)	rr	...	rrr	...	rrr	rrr	rrr	rr	rr	rr	rr	r
Zygnema sp. (sterile)	rrr	...	...	...	...	...	...	...	...	..	rrr	
Spirogyra sp. (sterile)	...	...	rrr	rrr	...	...	...	...	...	...	r	
Gonatozygon monotænium, De Bary	...	rr	...	...	..	...	...	..	...	...	rr	
Netrium interruptum, (Bréb.) Lütkem.	...	...	...	...	...	...	...	...	...	...	...	rrr
Roya cambrica, W. & G. S. West, var. *limnetica*, var. n.	...	...	rrr	...	...	rrr						
Closterium juncidum, Ralfs	...	...	...	...	rrr							
,, *Kützingii*, Bréb.	...	...	...	...	...	...	...	...	...	...	rrr	
,, *macilentum*, Bréb.	...	...	...	...	...	...	...	...	...	rrr	rrr	
Tetmemorus granulatus, (Bréb.) Ralfs	...	rr										
Euastrum bidentatum, Näg.	...	...	rrr									
,, *crassum*, (Bréb.) Kütz.	...	...	...	rrr								
,, *Didelta*, (Turp.) Ralfs	...	...	...	...	...	...	...	rrr				
Micrasterias papillifera, Bréb.	...	...	..	...	...	...	...	...	...	r		
,, *rotata*, (Grev.) Ralfs	rrr	...	rrr	...	...	rrr	...	...	rrr			
Cosmarium abbreviatum, Racib., var. *planctonicum*, W. & G. S. West	rr	rr	r	r	rr	...	rrr	r	r	r	c	cc
,, *bioculatum*, Bréb.	...	...	rr									
,, *reniforme*, (Ralfs) Arch.	...	...	...	...	...	...	rrr	...	...	...	rrr	rr

Arthrodesmus triangularis, Lagerh.	rrr	...	...	...	...	...	...	...	...	rr	rr	rr
„ „ var. *subtriangularis*, (Borge) W. & G. S. West	r	r	rr	rr	rrr	...	...	rrr				
Xanthidium armatum, (Bréb.) Rabenh., var. *cervicorne*, W. & G. S. West	rrr											
„ *antilopæum*, (Bréb.) Kütz., var. *depauperatum*, W. & G. S. West	...	...	...	...	...	...	...	...	...	...	rr	
Staurastrum anatinum, Cooke & Wills	...	...	...	...	...	...	...	...	...	...	...	rrr
„ *cuspidatum*, Bréb., var. *maximum*, West	c	c	c	r	r	rrr	...	r	r	r	c	c
„ *jaculiferum*, West (forma *triradiata*)	rr	r	r	r	r	rr	rr	c	c	c	ccc	c
„ *paradoxum*, Meyen	rr	r	r	r	rr	rr	r	c	cc	ccc	ccc	ccc
„ „ var. *cingulum*, W. & G. S. West	ccc	cc	c	cc	c	c	c	c	r	r	r	c
„ „ var. *longipes*, Nordst.	c	c	c	c	c	r	rr	rrr	rr	r	r	r
Spondylosium planum, (Wolle) nob.	...	rrr	rrr	...	...	...	...	...	rrr	...	r	
Gymnozyga moniliformis, Ehrenb.	...	rrr										
Hyalotheca mucosa, Ehrenb.	...	...	...	...	...	...	...	...	...	...	...	rrr
Ankistrodesmus falcatus, (Corda) Ralfs	...	...	rrr	rrr	...	...	rrr	...	...	...	rrr	rrr
„ „ var. *acicularis*, (A. Br.) G. S. West	...	...	rrr	...	...	...	rr					
„ „ var. *spirilliformis*, G. S. West	...	rrr	rrr	rrr	rrr	rrr	...	...	rrr	...	rrr	
Oocystis lacustris, Chodat	...	...	...	...	...	...	...	...	...	...	rr	
Nephrocytium lunatum, West	r	rr	rrr	...	...	...	...	...	rrr	...	...	rr
Sphærocystis Schroeteri, Chodat	rr	rr	rrr	rrr	...	...	...	rrr	rrr	...	rrr	r
Glœocystis gigas, (Kütz.) Lagerh.	...	...	...	...	...	...	...	rrr	...	rrr	rrr	rrr
Bacillarieæ.												
Cyclotella compta, Kütz.	...	...	r	r	rr	rrr	...	...	r	...	r	
Rhizosolenia morsa, W. & G. S. West	...	...	rr	rr	r	r	r	...	...	...	c	cc
Tabellaria fenestrata, (Lyngb.) Kütz.	...	...	...	...	...	...	...	rrr	rr	rr	r	r
„ *flocculosa*, (Roth) Kütz.	rrr	rrr	r	rr	rr	rr	...	r	r	r	c	r
Synedra pulchella, Kütz.	...	rrr	...	...	rrr	rr	rr	...	rr	r	r	
„ *radians*, (Kütz.) Grun.	...	...	c	r	rr	rr	r	r	r	r	r	r
Asterionella gracillima, Heib.	rrr	...	...	rrr	rrr	rrr	rrr	rr	rrr	r	c	r
Eunotia gracilis, (Ehrenb.) Rabenh.	...	...	rrr	...	rrr	...	rrr	...	r			
„ *lunaris*, (Ehrenb.) Grun.	...	...	...	...	...	...	. .	rr	...	...	rr	rr
„ *major*, (W. Sm.)	..	...	rr	...	rr							
Gomphonema intricatum, Kütz.	...	...	...	...	rrr	...	...	...	...	rrr		
Navicula major, Kütz	...	...	...	...	rrr	...	...	...	...	...	rr	
„ *viridis*, Kütz.	...	...	...	...	...	rrr						
Vanheurckia rhomboides, Bréb., var. *saxonica*, (Rabenh.) G. S. West	...	...	...	...	...	rrr	rr	rrr				
Surirella biseriata, Bréb.	...	...	...	...	...	rrr	...	rrr	...	...	rrr	
„ *robusta*, Ehrenb., var. *splendida*, (Ehrenb.) Van Heurck	...	...	...	rr	...	...	...	...	...	...	rr	

PHYTOPLANKTON FROM LOCH KATRINE (*continued*).

SPECIES.	1908.					1909.						
	August. 60° F. (=15·5° C.).	September. 56° F. (=13·3° C.).	October. 55° F. (=12·7° C.).	November. 50° F. (=10° C.).	December. 45° F. (=7·2° C.).	January. 43° F. (=6·1° C.).	February. 40° F. (=4·4° C.).	March. 39° F. (=3·9° C.).	April. 46° F. (=7·7° C.).	May. 46° F. (=7·7° C.).	June. 54° F. (=12·2° C.).	July. 60° F. (=15·5° C.).
Phæophyceæ.												
Stichoglœa olivacea, Chodat	...	...	...	...	...	...	...	...	rr	r	r	r
Myxophyceæ.												
Lyngbya contorta, Lemm., forma	...	...	...	...	rr	rr	r	rr	rrr			
Oscillatoria Agardhii, Gomont	...	...	...	...	...	...	...	...	...	r	rr	
Merismopedia glauca, (Ehrenb.) Näg.	...	...	rrr	...	...	...	...	rrr				
" *tenuissima*, Lemm.	...	rr	c	r	rr	rrr	...	...	...	...	rrr	r
Cœlosphærium Kützingianum, Näg.	ccc	ccc	c	c	r	rr	rr	rrr	rr	r	r	cc
Aphanocapsa delicatissima, sp. n.	...	...	...	...	...	...	...	...	...	...	...	rrr
Aphanothece nidulans, Richter, var. *endophytica*, var. n.	r	c	c	r	rr	...	...	...	...	...	...	rr
Microcystis Flos-aquæ, (Wittr.) Kirchn.	...	...	...	...	...	...	...	...	...	...	rrr	
Flagellata.												
Dinobryon cylindricum, Imhof	...	...	...	...	...	...	...	...	..	rr	rrr	rrr
" " var. *divergens*, (Imhof) Lemm.	..	...	...	...	...	...	...	...	...	...	rr	r
Peridinieæ.												
Peridinium inconspicuum, Lemm.	...	...	...	...	...	...	...	...	...	...	r	r
" *Willei*, Huitf.-Kaas	r	rrr	...	...	...	...	..	rr	r	c	cc	ccc

The phases of the plankton of Loch Katrine, although distinct, are difficult to demarcate. It seems best to subdivide the year into three periods, as follows :—

I. *December–March* (cold period, with continuous fall in temperature). Amount of phytoplankton small. Minimum of Chlorophyceæ and rapid diminution of *Cœlosphærium* up to the middle of March. After February, Desmids and *Peridinium Willei* begin to increase rapidly. *Rhizosolenia morsa* has a first maximum from December to February, and then disappears.

Fig. 4.

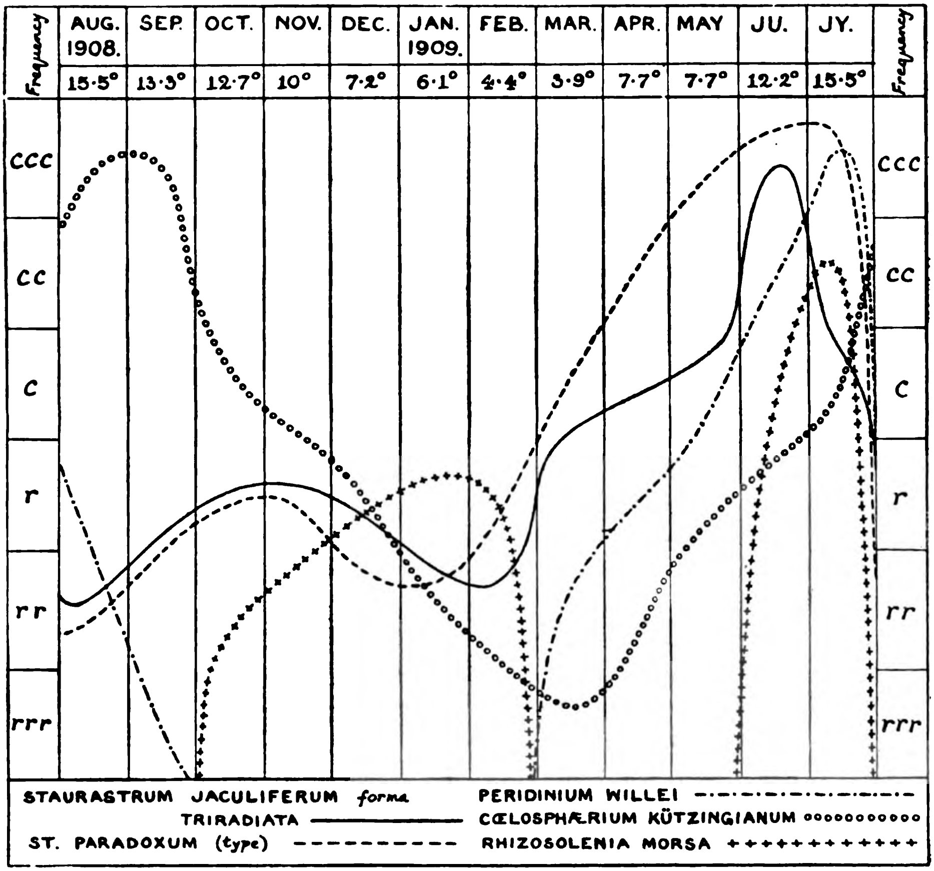

Chart of the periodicity of five of the dominant constituents of the phytoplankton of Loch Katrine. The temperatures are in degrees Centigrade.

II. *April–July* (continuous rise in temperature). Great increase in Desmids and in *Peridinium Willei*. In June and July there is a striking Desmid-plankton. *Rhizosolenia morsa* appears again abundantly in June, and attains a second maximum in July. *Cœlosphærium* rapidly increasing in amount.

III. *August–November* (autumnal fall in temperature). *Cœlosphærium* attains its maximum and dominates the plankton in August and September, after which it rapidly decreases in amount. *Peridinium Willei* disappears in the latter month. Slight maximum of some Desmids from September to November.

Of the 16 species of Bacillarieæ, *Synedra radians* is common in October, *Tabellaria flocculosa* and *Asterionella gracillima* are both common in June, and *Rhizosolenia morsa* attains a considerable maximum in June and July. The latter has also a smaller maximum from December to February, disappearing entirely from the plankton from the end of February to the beginning of June. All the other Diatoms are relatively rare.

Of the Chlorophyceæ only the Desmids are of importance. A sterile species of *Œdogonium* was common in the autumn, but all other Green Algæ except Desmids are at all times comparatively scarce. The most abundant of the Desmids was *Staurastrum paradoxum* and its vars. *cingulum* and *longipes*, but *St. cuspidatum* var. *maximum* and *Cosmarium abbreviatum* var. *planctonicum* also occurred in great quantity in the warmer months.

The Myxophyceæ were represented by 8 species, of which *Cœlosphærium Kützingianum* alone occurred in great quantity. This Alga was never absent from the plankton, and at the time of its great maximum in August and September is the dominating constituent. As in the case of Loch Lomond, the colonies possessed the endophytic *Aphanothece nidulans* var. *endophytica*. Special attention should be called to a form of *Lyngbya contorta* which occurred only in the cold period from December to April, and was most abundant in February. *Merismopedia tenuissima* was common in October.

Of the flagellated organisms, *Peridinium Willei* occurs in great abundance in June and July, but is entirely absent during the fall in temperature from October to February.

6. Loch Earn, Perthshire.

This lake, which is situated at 317 feet above sea-level, is 7 miles in length and rather more than half a mile in breadth. The surrounding mountains vary from about 2000 feet to 3224 feet (Ben Voirlich), and the shores of the lake consist of gravel and drift. The area of the lake is 3·91 square miles; its main depth is 137·8 feet, and its greatest depth 287 feet.

Owing to unforseen accidents collections were obtained from this lake only on three occasions.

Aug. 21*st*, 1908. Temp. of water 60° F. (=15·5° C.). Mixed plankton containing numerous Desmids and an abundance of *Ceratium Hirundinella*. *Staurastrum cuspidatum* var. *maximum* was particularly common, and quantities of *Cœlosphærium* were present.

Dec. 10*th*, 1908. Temp. of water 45° F. (=7·2° C.). Material contained a large amount of fine detritus. Few Desmids and few Diatoms present. Most probably this collection was improperly obtained.

Jan. 22*nd*, 1909. Temp. of water 41° F. (=5° C.). Very dirty material, similar to previous collection.

TABLE OF PHYTOPLANKTON FROM LOCH EARN.

SPECIES.	Aug. 1908. 60° F. (=15·5° C.)	Dec. 1908. 45° F. (=7·2° C.)	Jan. 1909. 41° F. (=5° C.)
Chlorophyceæ.			
Œdogonium sp. (sterile)	r		
Spirogyra sp. (sterile)	rr		
Cosmarium abbreviatum, Racib., var. *planctonicum*, W. & G. S. West	c	...	rr
,, *granatum*, Bréb.	...	...	rrr
Staurastrum cuspidatum, Bréb., var. *maximum*, West	cc	r	r
,, *jaculiferum*, West, forma *biradiata*	r	rrr	rrr
,, *lunatum*, Ralfs	r		
Spondylosium planum, (Wolle) nob.	rrr		
Nephrocytium lunatum, West	rr		
Dictyosphærium pulchellum, Wood	rrr		
Sphærocystis Schroeteri, Chodat	rrr	...	rrr
Bacillarieæ.			
Tabellaria fenestrata, (Lyngb.) Kütz.	rrr		
,, *flocculosa*, (Roth) Kütz.	r	...	rr
Synedra Acus, (Kütz.) Grun.	r		
,, *Ulna*, (Nitzsch) Ehrenb.	rr	rrr	
Eunotia lunaris, (Ehrenb.) Grun.	r		
Gomphonema intricatum, Kütz.	r		
Vanheurckia rhomboides, Bréb., var. *saxonica*, (Rabenh.) G. S. West	r		
Cocconema cymbiforme, Ehrenb.	r		
Surirella biseriata, Bréb.	r		
Myxophyceæ.			
Oscillatoria Agardhii, Gomont	r		
Cœlosphærium Kützingianum, Näg.	cc	r	rr
Gomphosphæria lacustris, Chodat	rrr		
Aphanothece nidulans, Richter, var. *endophytica*, var. n.	c	rr	rr
Peridinieæ.			
Ceratium Hirundinella, O. F. Müller	c		
Peridinium Willei, Huitf.-Kaas	rr		

It is to be regretted that the collections from Loch Earn were not much more complete, as it is impossible from the available material to draw any conclusions regarding the periodicity of the phytoplankton.

7. Loch Lubnaig, Perthshire.

This loch is 4½ miles in length by about half a mile broad at its widest part, and is 405 feet above sea-level. On its western side is Ben Vane (2685 feet), and on its eastern side Beinn Each (2660 feet), the summits of these mountains being about two miles from the lake.

The collections from this lake were also incomplete, but as they were made from August to October 1908 and from January to April 1909, it is possible to form some idea of the periodicity of the phytoplankton.

Aug. 15*th*, 1908. Temp. of water 61° F. (=16·1° C.). The plankton consisted mostly of *Dinobryon cylindricum* and *Anabæna Flos-aquæ*, amongst which were numerous Rotifers and much organic detritus.

Sept. 16*th*, 1908. Temp. of water 54° F. (=12·2° C.). The material consisted almost entirely of Entomostraca. *Tabellaria flocculosa* and *Dinobryon cylindricum* were present in small quantity, and there was a little organic detritus.

Oct. 16*th*, 1908. Temp. of water 56° F. (=13·3° C.). Much organic detritus and broken sterile filaments of *Œdogonium*. Very few Diatoms, and few Rotifers and Entomostraca.

Jan. 20*th*, 1909. Temp. of water 34° F. (=1·1° C.). Plankton practically absent, collection consisting of organic detritus, but we doubt whether the material was collected in a proper manner. Two or three species of Diatoms were observed, and one or two specimens of Rotifers and Crustacea.

Feb. 21*st*, 1909. Temp. of water 36° F. (=2·2° C.). Scarcely any phytoplankton, but much organic and mineral detritus. A few species of Diatoms. No Rotifers. Defective material?

March 16*th*, 1909. Temp. of water 36° F. (=2·2° C.). Phytoplankton mostly Diatoms, of which *Surirella biseriata* and *Tabellaria flocculosa* were most conspicuous. A few species of Desmids were also present in small quantity. Very few Rotifers.

April 20*th*, 1909. Temp. of water 44° F. (=6·6° C.). Phytoplankton mostly Diatoms, of which *Tabellaria fenestrata* is dominant and *T. flocculosa* less abundant. *Synedra Ulna* was common, and many of the valves were curiously bent and deformed. *Dinobryon cylindricum* and *Clothrix zonata* were both frequent. Few Rotifers were present, and there was a great admixture of organic detritus.

Altogether 37 species were observed in the phytoplankton of Loch Lubnaig, mostly Green Algæ and Diatoms. Most of the Chlorophyceæ occurred in the August collection, whereas the Diatoms were most numerous and in greatest variety in March. The data at our disposal are at present, however, insufficient to enable us to make any definite statement regarding the periodicity of the phytoplankton of this lake.

Table of Phytoplankton from Loch Lubnaig.

Species.	1908.			1909.			
	Aug.	Sept.	Oct.	Jan.	Feb.	Mar.	Apr.
Chlorophyceæ.							
Œdogonium sp. (sterile)	rr	rr	c	...	rr	rrr	rr
Ulothrix zonata, (Web. & Mohr) Kütz	...	...	...	...	...	...	r
„ *subtilis*, Kütz., var. *variabilis*, (Kütz.) Kirchn...	...	...	...	rrr	rrr		
Spirogyra sp. (sterile)	r	...	rr				
Mougeotia sp. (sterile)	r	...	...	...	...	rr	rrr
Gonatozygon monotænium, De Bary	r						
Closterium Kützingii, Bréb.	...	...	...	...	...	rrr	
Euastrum bidentatum, Näg.	...	...	...	...	...	rrr	
Micrasterias denticulata, Bréb.	...	...	...	...	...	rrr	
Cosmarium ochthodes, Nordst.	...	...	...	...	...	rrr	
Xanthidium antilopæum, (Bréb.) Kütz., var. *depauperatum*, W. & G. S. West	r						
Hyalotheca mucosa, Ehrenb.	rrr	...	...	...	...	rrr	
Gymnozyga moniliformis, Ehrenb.	rrr						
Glæocystis gigas, (Kütz.) Lagerh.	c						
Bacillarieæ.							
Tetracyclus lacustris, Ralfs, var. *emarginata*	...	...	...	...	...	rrr	
Tabellaria fenestrata, (Lyngb.) Kütz.	r	...	...	rrr	...	rr	c
„ *flocculosa*, (Roth) Kütz.	c	rr	rrr	rrr	r	c	r
Synedra radians, (Kütz.) Grun.	...	...	...	...	...	r	rrr
„ *Ulna*, (Nitzsch) Ehrenb.	...	...	rr	rrr	r	r	c
Asterionella gracillima, Heib.	...	...	...	...	...	rrr	
Ceratoneis Arcus, (Ehrenb.) Kütz., var. *Amphioxys*, (Rabenh.) De Toni	...	...	...	...	rrr	...	rrr
Eunotia gracilis, (Ehrenb.) Rabenh.	...	...	...	...	...	rrr	
„ *pectinalis*, (Kütz.) Rabenh.	...	...	rr	...	...	rr	rrr
„ *lunaris*, (Ehrenb.) Grun.	...	...	...	...	rr	rr	rr
Gomphonema constrictum, Ehrenb.	...	...	...	...	...	rr	
„ *intricatum*, Kütz.	...	...	...	...	...	rrr	rr
Navicula major, Kütz.	...	...	...	rrr	...	rrr	
Vanheurckia rhomboides, Bréb., var. *saxonica*, (Rabenh.) G. S. West	...	...	...	...	...	rrr	
Cocconema cuspidatum, (Kütz.) G. S. West	...	...	...	...	...	rrr	
Nitzschia Sigma, (Kütz.) W. Sm.	...	...	...	...	...	rr	
Surirella biseriata, Bréb.	...	...	...	rrr	...	r	rrr
„ *linearis*, W. Sm.	...	...	...	...	...	rr	
Myxophyceæ.							
Anabæna Flos-aquæ, (Lyngb.) Bréb.	c						
Oscillatoria Agardhii, Gomont	rrr	...	...	...	..	rrr	rr
Flagellata.							
Dinobryon cylindricum, Imhof	c	rr	...	...	...	rr	r
Synura uvella, Ehrenb.	...	...	...	...	...	rr	rr
Peridinieæ.							
Peridinium Willei, Huitf.-Kaas	rr						

GENERAL CONCLUSIONS CONCERNING THE PHYTOPLANKTON OF BRITISH LAKES AND ITS PERIODICITY.

The following conclusions are not merely drawn from the data afforded by the collections from the seven lakes previously described, but also from our observations on the plankton of dozens of other lakes in all the lake-areas of the British Islands.

The coldest water-temperatures occur from February to April and are frequently met with in the month of March. The highest temperatures of the water are as a rule in July and August.

The greatest actual bulk of plankton occurs when the Entomostraca are most abundant, but the greatest amount of phytoplankton is found in the late summer and autumn, during the autumnal decline in temperature.

In all the lakes examined there are certain more or less well-marked phases in the phytoplankton, each phase dominated by one or more of the constituents. It is not an easy matter to compare the phytoplankton of one lake with that of another, as the annual phases of one probably do not correspond with those of the other. Take three of the English lakes—Ennerdale Water, Wastwater, and Windermere; Ennerdale Water has 91 species in the phytoplankton, Wastwater 50 species, and Windermere 65 species; yet only 15 species are common to all three lakes, and the dominant species are for the most part different.

CHLOROPHYCEÆ.—Almost all the Green Algæ attain their maximum vegetative abundance during the autumnal fall in temperature.

a. *Desmidiaceæ.* The Desmid-phase is during the decline in temperature from August to November, and they are most abundant in September (more rarely in August), although in some lakes certain species reach their maximum in June. The plankton Desmids appear to require very similar physiological conditions, and the maximum vegetative activity of the group as a whole is just after the highest temperature has been reached: that is, in September, or in some cases in early October. In some lakes certain species are perennial, but these also have their maximum at the same season as the others. We have previously pointed out that this is approximately the period of abundance of Desmids in the littoral region and in the bogs *.

b. *Protococcales.* Of this group there are few genera of importance in the plankton, and the frequent pond species of *Scenedesmus*, *Pediastrum*, and *Crucigenia* are very uncommon except in the shallower and more lowland lakes. *Sphærocystis Schroeteri* and *Dictyosphærium pulchellum* are mostly summer and autumn constituents in the larger lakes. *Elakatothrix gelatinosa*, which is found only in Wastwater, and *Tetraspora limnetica*, which occurs only in Ennerdale Water, are both summer forms. *Botryococcus Braunii* is not often abundant in the British lakes and is a late summer form.

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* W. & G. S. West, in 'The Naturalist,' May 1909, p. 192.

BACILLARIEÆ.—Only in the more contaminated lakes do the Diatoms attain great maxima comparable to the vast quantities which periodically appear in many of the central European lakes. The Pennate Diatoms are much more numerous, and for the most part much more conspicuous than the Centric Diatoms.

The evidence at present available shows that although many of the plankton-species of Diatoms occur in greatest quantity in the spring, some of them attain their maxima in the summer and autumn, and several of them have a double maximum, one in the spring and the other in the autumn. An instance of the latter is afforded by *Asterionella gracillima* in Windermere *, in which the spring maximum is of greater bulk but not so prolonged as the autumn maximum.

The double maximum (spring and autumn) of Diatoms in general does not appear to be so marked in the freshwater plankton as in the marine plankton †, and the double maximum of the *same species*, as instanced by *Asterionella gracillima*, *Cyclotella compta*, *Rhizosolenia morsa*, and others, is of unusual interest.

A number of the freshwater Diatoms are perennial constituents of the plankton of certain lakes and can be obtained in a living condition all the year round. Some of them attain their maxima in the spring and others in the autumn, and sometimes in both.

The occurrence of *Rhizosolenia morsa* is very interesting. It apparently had a double maximum in four of the lakes examined. In Ennerdale Water it had a small maximum in April (water-temperature 5·5° C.), and a much larger one from October to November (10°–8·3° C.); in Windermere it was rare in May (4·4° C.) and very rare in September (14·4° C.), not occurring in any other months; in Wastwater there was a small spring maximum in May (7·8° C.) and a large maximum in December (8·9° C.), in Loch Katrine there was a moderate January–February maximum (6·1°–4·4° C.) and a larger July maximum (15·5° C.). The fact that the autumn maximum is the larger is of interest in comparison with the marine plankton of Western Europe, in which the autumn maximum of Diatoms consists largely of species of the genus *Rhizosolenia*. Of interest, also, is the occurrence of this same species in the Yan Yean Reservoir, Victoria, with only one maximum, which occurs when the temperature of the water is at its highest (23·3° C.) *.

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* We have already discussed this double maximum (*cf.* W. & G. S. West, *l. c.* 1909, pp. 193, 260, and 261), which has likewise been observed in *Fragilaria crotonensis* by Wesenberg-Lund ('Plankton Investigations of Danish Lakes,' Copenhagen, 1908, p. 50).

† Consult Herdman, Presidential Address to the Linnean Society, Proc. Linn. Soc. 1908, pp. 23, 24; also Herdman & Riddell, in Trans. Biol. Soc. Liverpool, xxv. 1911, pp. 63-65.

Melosira granulata is equally interesting in its occurrence, sometimes appearing in such quantity as to give a *Melosira*-phase to the plankton. In Windermere it has a large maximum in April (1·7° C.); in Loch Lomond the maximum is from May to June (5°–13·3° C.). On the other hand, in the plankton of the Yan Yean Reservoir, Victoria, *Melosira granulata* attained its maximum abundance in the middle of the warm period with a water-temperature of 21° C.

The apparent erratic increase of the two above-mentioned Diatoms in relation to the water-temperatures would appear to lend support to Whipple's conclusion that temperature is of so little importance to Diatoms that it does not affect their seasonal distribution †. But in contrast to this, it is a matter of common observation that most Diatoms, even the Centric ones, have a decided preference for cool or even cold water, and that many of the plankton Diatoms attain their maxima with much constancy between certain limits of temperature. So that taking into consideration the multitude of observations on the occurrence of Diatoms in relation to the temperature, we are compelled to agree with Kofoid ‡ that there are times when temperature is more important than food as a factor controlling the growth of Diatoms.

MYXOPHYCEÆ.—Most of the Blue-green Algæ are warm-period forms, occurring in greatest abundance in the early part of the autumnal decline in temperature. The only species which occurs in sufficient quantity to become dominant is *Cœlosphærium Kützingianum* §, and this constituent occurs principally in the slightly contaminated lakes, such as Windermere, Loch Lomond, Loch Katrine, and others ‖. Sometimes *Gomphosphæria lacustris* is fairly abundant in some of the low-lying lakes, and in one instance presented a considerable August maximum.

Species of *Anabæna*, *Aphanizomenon*, *Oscillatoria*, etc. are for the most part only of secondary importance in the British lakes, attaining great maxima only on those sporadic occasions which are signalized by great masses of "water-bloom." This phenomenon, which does not occur in the deep, uncontaminated lakes, yet requires thorough investigation, and it would appear that its complete scientific explanation can only be obtained by simultaneous biological and chemical observations extending over a considerable period of time (probably 15–20 years).

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* G. S. West, in Journ. Linn. Soc., Bot. xxxix. 1909, p. 21.

† G. C. Whipple, in Technol. Quart. vii. 1894, p. 214.

‡ C. A. Kofoid, "The Plankton of the Illinois River," Bull. Ill. State Labor. Urbana, Illinois, viii. article 1, May 1908, p. 54.

§ *Gomphosphæria Nägeliana* may occur in quantity in some of the slightly contaminated lakes, sometimes mixed with *Cœlosphærium Kützingianum* or even entirely replacing that species.

‖ Such as Lough Neagh.

PERIDINIEÆ.—*Ceratium Hirundinella*, which is so ubiquitous in almost every part of the world, occurs only in certain lakes of the British lake-areas. It occurs in most of the English lakes, but is entirely absent from Wastwater, and very probably absent from Buttermere and Crummock Water. It is also a notable absentee from the larger lakes of North Wales.

When this Peridinian does occur, it is a summer form with a small maximum in August or September. It completely disappears from the plankton in the winter months, entering into an encysted state in December in the larger lakes, or earlier in the smaller bodies of water *, and re-appearing about April or May. In the lakes of more southern climates it is a perennial constituent of the plankton †. We have not seen any seasonal form-variations of this organism such as those described by Wesenberg-Lund from the Danish lakes ‡, although several forms frequently occur simultaneously in some of the lakes.

Ceratium cornutum is a similar summer form.

Peridinium Willei is the most abundant and widely-distributed species of the genus in the English and Welsh lakes, and in some of the Scottish lakes. It is a summer form, with a considerable maximum at some period from July to September, and, as in the case of *Ceratium Hirundinella*, it is a perennial constituent of the lake-plankton of more southern latitudes.

Species of *Peridinium*, like many Diatoms, do not attain a universal maximum at one definite period of the year, but the various species reach their greatest vegetative development at different times of the year §. In some of the pools of the English Midlands there is a summer species (a var. of *P. cinctum*), a spring species (*P. anglicum*), and a very early spring—almost a winter—species (*P. aciculiferum*), each of which has been shown to form resting-cysts at the close of the vegetative period, even though the vegetative periods are all at different seasons.

* * * * * * * * *

In studying the phytoplankton of lakes difficulties of comparison are everywhere met with, even when dealing with lakes in the same area. The constituents of the phytoplankton are not the same in all, and species which occur abundantly in one lake may not occur in any of the others.

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* G. S. West, "A Biol. Investigation of the Peridin. of Sutton Park, Warwicksh.," New Phytologist, viii. 1909, p. 193.

† Brahm & Zederbauer, in Verhandl. der k. k. zool.-bot. Ges. Wien, 1904, p. 48; G. Entz, in Result. der wiss. Erforschung des Balatonsee, Bd. ii. Budapest, 1904; Lemmermann, in Archiv für Hydrobiol. u. Planktonkunde, iii. 1908, p. 379.

‡ Wesenberg-Lund, 'Plankton Investigations of Danish Lakes,' Copenhagen, 1908, p. 69.

§ G. S. West, in 'New Phytologist,' viii. 1909, p. 194, f. 126.

These differences in the constituents are partly territorial and partly local, and are in part due to the rigorous conditions which govern the distribution of so many of the purely aquatic Algæ. We have already shown by a carefully collated mass of evidence that a territorial distinction occurs in those lakes situated in drainage-basins in which the rocks are older than the Carboniferous. Some of these lakes possess a Desmid-flora in the plankton such as does not occur in any lakes which are situated in basins of newer formations. Local differences between two lakes in similar basins are frequently due to contamination of the water, some groups of Algæ thriving under such circumstances whereas others are greatly reduced or eliminated.

The varying nature of the plankton of different lakes is to be correlated with the fact that the various groups of Algæ require different physiological conditions for rapid multiplication. For instance, the factors which favour the prolific growth of Desmids are not those which enable an equally rapid increase in the majority of Diatoms; and likewise those factors which favour the great multiplication of one species of Diatom are not favourable for a similar increase in another.

A careful study of the constituents of the phytoplankton in relation to the lake-basins has convinced us that *the factor of greatest importance in both the qualitative and quantitative distribution of plankton is the amount of dissolved salts present in the water.* The highest percentage of dissolved salts is found in those lakes which are slightly contaminated from adjacent villages and farms, and we have before remarked upon the greater quantitative bulk of the plankton of such lakes *.

Slightly contaminated lakes contain a greater number of Diatoms than uncontaminated lakes, and as a rule some of them are perennial constituents of the plankton. A few species frequently have enormous maxima, particularly *Asterionella gracillima*, *Tabellaria fenestrata* var. *asterionelloides*, and *Melosira granulata*, such maxima being probably due to the abundance of nitrates. The Desmida-flora of these lakes is usually poor, and few species ever occur in quantity.

On the other hand, *uncontaminated lakes* (or lakes with very pure water) contain fewer Diatoms, and such as do occur in the plankton rarely attain even a small maximum. The Desmids are generally numerous and there is often a rich Desmid-plankton. The lakes of the Carnarvonshire mountains are excellent examples, being amongst the least contaminated of all the British lakes. Hence in these lakes there are relatively few Diatoms (only 11·1 per cent. out of a total of 162 species) and many Desmids (62·4 per cent.), and some of them possess a very rich Desmid-plankton.

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* W. & G. S. West, in Proc. Roy. Soc. B, vol. lxxxi. 1909, p. 175; 'Naturalist,' Sept. 1909, p. 330.

Lakes which possess a mixed plankton of Diatoms and Desmids are probably of an intermediate character with regard to the nature and amount of the dissolved salts in the water. The Myxophyceæ are to a great extent absent from the lakes with very pure water, but an examination of the occurrence and distribution of the plankton-species of Blue-green Algæ indicates that the factors which control their relative abundance are somewhat different from those which govern the prolific occurrence of Diatoms.

There is also a considerable reduction in the amount of *Asterionella* and of the star-dispositions of *Tabellaria*, or even an entire absence of them from lakes with pure water. These two genera of Diatoms are absent from the large African lakes, most probably owing to too high a temperature of the water *, but their absence from certain British lakes appears to be directly concerned with purity of the water. Wastwater furnishes a good example of a lake from which these star-dispositions of the frustules of Diatoms are absent.

The comparative and periodic study of the plankton of the British lakes has afforded evidence in the elucidation of the fact which we first definitely mentioned in 1905 †, and subsequently expounded at greater length ‡, namely, that "the rich Desmid-areas correspond with the Precambrian and Older Palæozoic outcrops (together with the intrusive Igneous material)." It is the occurrence of a rich Desmid-plankton only in those lakes which are least contaminated, and have the purest water, which has led us to the conclusion that the principal factor controlling the abundance of Desmids is the nature and amount of the dissolved salts in the water. Hence it becomes obvious why the rich Desmid-areas should be on the old formations, as for the most part the drainage-water of such areas contains much less in the way of dissolved mineral salts than that of areas of the newer formations. This is due in a great measure to the relative hardness of these rocks, which in itself is due to their antiquity, and also partially to the comparative absence of lime, a substance which is distinctly unfavourable to the growth of the majority of Desmids.

It must, however, be emphasized that not all the lakes of one of these rich Desmid-areas contain a rich Desmid-plankton. Some are too much contaminated by the sewage from farms and villages, and others which may have no such contamination, but yet have no Desmid-plankton, probably receive drainage-water which percolates through certain strata from which too much mineral matter is removed in solution.

Thus the comparative richness of the Desmid-flora of the various parts of

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* G. S. West, in Journ. Linn. Soc., Bot. xxxviii. 1907, p. 84.

† W. & G. S. West, in Trans. Roy. Soc. Edin. xli. part 3, 1905, p. 515.

‡ W. & G. S. West, in Proc. Roy. Soc. B, vol. lxxxi. 1909, pp. 195–201.

the British Islands is very largely (but not entirely) dependent upon the presence of the requisite physiological conditions for the growth of these plants, such conditions being in all probability determined by the degree of concentration of the dissolved salts in the water.

It seems likely that with our present knowledge of the occurrence and distribution of British Desmids the whole matter could be definitely settled by a careful and exact chemical investigation of the waters of the lake-areas, both of the lakes and the bogs.

Description of some New Forms found in the Phytoplankton.

The following new forms have been observed during the foregoing investigation :—

1. Roya cambrica, W. & G. S. West, in Journ. Bot. 1903, p. 41, t. 446. f. 11; Monogr. Brit. Desm. i. 1904, p. 108, t. 10. f. 31.

Forma limnetica, W. & G. S. West. (Pl. **19**. figs. 11, 12.)
Forma apicibus cellularum valde truncatis, pyrenoidii in cellula tota 10.
Long. cell. 141–183 μ; lat. med. cell. 6 μ; lat. apic. 4·4–5 μ.
Hab. Loch Katrine (June 1909).

2. Spondylosium planum, (Wolle) W. & G. S. West. *Sphærozosma pulchrum*, Bail., var. *planum*, Wolle, Desm. U. S. 1884, p. 29, t. 4. ff. 3, 4. *Spondylosium pulchrum*, (Bail.) Arch., var. *planum*, W. & G. S. West, in Journ. Linn. Soc., Bot. xxxiii. 1898, p. 311; *ibid.* xxxv. 1903, p. 551; etc. *Spondylosium pulchrum*, Bachmann, in Archiv für Hydrobiol. u. Planktonkunde, iii. 1907, p. 30.

S. mediocre, filis non tortis, sine vagina mucosa; cellulæ circiter $1\frac{1}{6}$-plo latiores quam longæ, subquadratæ, angulis rotundatis, profunde constrictæ, sinu aperto et obtuso; semicellulæ transverse oblongæ, angulis rotundatis, apice recto; semicellulæ a vertice visæ oblongæ polis rotundatis, a latere visæ subcirculares; membrana glabra.

Long. cell. 11·5–19·5 μ; lat. 12–25 μ; lat. isthm. 5–11·5 μ; crass. 6–11 μ. (Pl. **19**. figs. 5–8.)

Hab. Fairly general in the plankton of all the British lake-areas.

We have placed this Desmid as a species because there is no possibility of confusing it with any other *Spondylosium*. It varies much in size, but retains its characters with great constancy. It has little, if any, relationship to *S. pulchrum*, (Bail.) Arch., differing in its much smaller size, in its plane and untwisted filaments, and in the flattened closely applied apices of the semicells. The semicells are of a different form from those of *S. pulchrum*,

and the cells are proportionately longer. Moreover, although this Desmid is common in the plankton of the British lakes, typical *S. pulchrum* does not exist in any part of the British Islands, or even in Europe.

3. ANKISTRODESMUS TORTILIS, W. & G. S. West. (Pl. **19**. figs. 9, 10.)

Cellulæ in coloniis parvis tortilibus subelongatis sublaxe aggregatæ, inter algas limneticas repertæ, singulæ minutæ, angustissimæ et acutissimæ, spiraliter contortæ, anfractæ 1–1⅙; chromatophora pallide viridia sine pyrenoidiis.

Long. cell. 12–18 μ; lat. cell. 0·3–0·5 μ.

Hab. Ennerdale Water, Cumberland (May and Aug. 1909).

This minute species is characterised by the spirally twisted colonies, reminding one to some extent of a bit of yarn or a wisp of wool. The cells are very minute, with a pale green chloroplast, and are spirally twisted to the extent of one, or rather more than one, complete spiral. Each individual cell when isolated is very like a miniature representation of the solitary *A. falcatus* var. *spirilliformis*.

4. TETRASPORA LIMNETICA, W. & G. S. West. (Pl. **19**. fig. 13.)

Coloniæ parvæ, globosæ, subglobosæ vel indistincte lobatæ, libere natantes inter alias algas limneticas; cellulæ parvæ, globosæ, subconfertæ, indistincte 2–4-aggregatæ; pseudocilia distincta et breva.

Diam. colon. 124–220 μ; diam. cell. 4 μ.

Hab. Ennerdale Water, Cumberland (Aug. 1908).

This tiny limnetic species seems quite unlike any other, and can be compared only with *T. lacustris*, Lemm., from which it differs in its more rounded colonies, with much more numerous and smaller cells, and in its distinct pseudocilia.

5. APHANOCAPSA DELICATISSIMA, W. & G. S. West. (Pl. **19**. figs. 2, 3.)

Coloniæ parvæ, subellipsoideæ, libere natantes, tegumento firmo gelatinoso ochraceo et hyalino; cellula minutissima sphærica solitaria geminatave, subconferta; cytioplasma homogeneum et læte æruginosum.

Long. colon. 18–32 μ, lat. 14–23 μ; diam. cell. 0·5 μ.

Hab. Wastwater, Cumberland (Jan. 1910).

This minute species is characterised by its free-floating habit and the minuteness of its cells. It should be compared with *A. elachista*, W. & G. S. West, from which it differs in the cells being only one-third the size, and in the more crowded colony.

6. APHANOCAPSA ELACHISTA, W. & G. S. West, "Some Freshw. Alg. W. Indies," in Journ. Linn. Soc., Bot. xxx. 1894, p. 276, t. 15. ff. 9, 10.

Var. CONFERTA, W. & G. S. West. (Pl. **19**. fig. 1.)

Var. cellulis multo magis confertis.

Long. colon. 73 μ, lat. 52 μ; diam. cell. 1·6–2 μ.

Hab. Loch Katrine (March 1909).

This variety differs only in the more crowded disposition of the cells, which are of approximately the same density as in *A. delicatissima*.

7. APHANOTHECE NIDULANS, P. Richter, in Wittr. & Nordst. Alg. Exsic. 1884, no. 694.

Var. ENDOPHYTICA, W. & G. S. West. (Pl. **19**. fig. 14.)

Var. habitu endophytico intra colonias *Cœlosphærii Kützingiani*.

Long. cell. 2·5–4·5 μ; lat. cell. 0·8–1 μ.

Hab. Loch Lomond, Loch Katrine, Lough Neagh, etc., occurring as an endophyte within the colonies of *Cœlosphærium Kützingianum* wherever that Alga attains a large maximum.

The cells are of precisely the same form and size as many of the rod-shaped bacteria which frequent the gelatinous colonies of Algæ, but they are of a brilliant blue-green colour.

[We wish to emphasize the fact that the cells of this endophytic *Aphanothece* are not bacteria. This is the more necessary as rod-shaped bacteria occur commonly in and upon the colonies of *Cœlosphærium* and *Gomphosphæria*.

It is possible that the "Bazillus sp. I" described by Bachmann (Archiv für Hydrobiol. u. Planktonk. iii. 1907, p. 78, and p. 60, fig. iii 5) as occurring in the colonies of *Gomphosphæria Nägeliana* is identical with *Aphanothece nidulans* var. *endophytica*.

It would seem that the blue-green colour is the only outstanding feature which distinguishes species of *Aphanothece* from species of *Bacillus*, and as all the above specimens were brilliantly coloured we have referred them to *Aphanothece*.—W. & G. S. WEST, 28th April, 1912.]

EXPLANATION OF PLATE 19.

Fig. 1. *Aphanocapsa elachista*, W. & G. S. West, var. *conferta*, var. n. × 500.

2–3. *Aphanocapsa delicatissima*, sp. n. × 1000.

4. *Plectonema Boryanum*, Gomont. × 500.

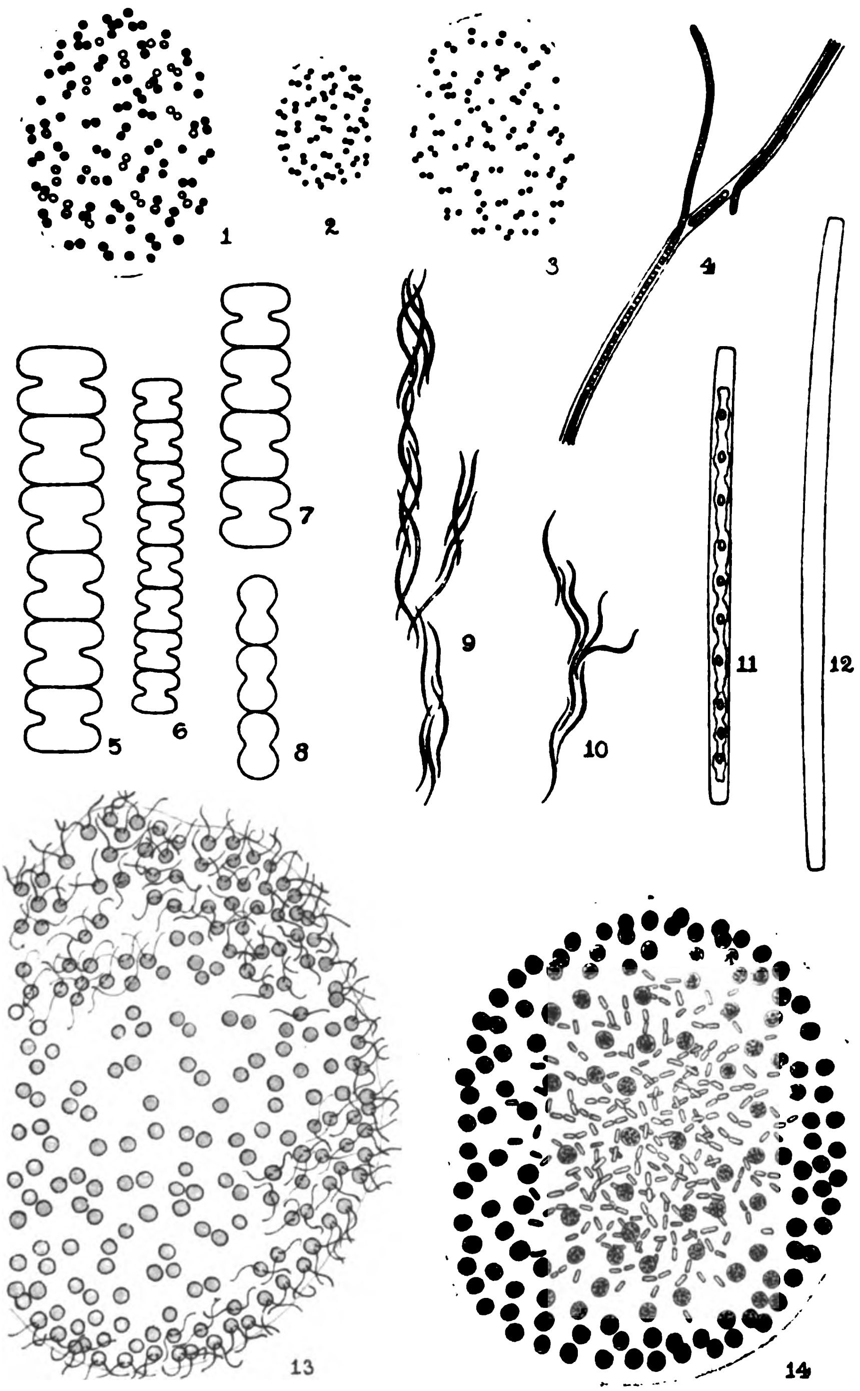
5–8. *Spondylosium planum*, (Wolle) nob. × 500.

9–10. *Ankistrodesmus tortilis*, sp. n. × 1000.

11–12. *Roya cambrica*, W. & G. S. West, forma *limnetica*. × 500.

13. *Tetraspora limnetica*, sp. n. × 500. The pseudocilia are not shown on all the cells.

14. *Aphanothece nidulans*, P. Richter, var. *endophytica*, var. n., within the colony of *Cœlosphærium Kützingianum*. × 500.



G. S. West, del.
Grout, Intaglio et imp.

FRESH WATER PHYTOPLANKTON.